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Telephone: Colmore 4274-4275 Telegrams: CIRA
The B.C.I.R.A. Scottish Laboratories are:—
Foundry Technical Institute, Meek's Road, Falkirk
Telephone: 332

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British and German Foundry Technology

We have refrained in the past from commenting upon the low level of German research work since the advent of the Nazis, because here and there the former excellent standard has been maintained. It was after reading Gillett's leading article in "Metals and Alloys," that we decided to make a survey of a year's issues of "Die Giesserei," the leading German foundry journal, to satisfy ourselves, whether or not Gillett's conclusions are correct. Dr. Gillett, besides being an editor of outstanding ability, is also a Professor at the Battelle Memorial Institute—to-day the world's leading centre for foundry and general metallurgical research. Here are his views on the subject.

"The United States will have to produce a greater proportion of the new fundamental information upon which future progress will be based, than heretofore. Of the countries overrun by the invaders, only France was of much importance in research and development. Her metallurgical journals appear to have ceased publication, nor is it likely that anything is being done worthy of publication. Sweden continues to record important matters in the 'Jernkontorets Annaler.' Of the belligerents, England maintains her excellent engineering and metallurgical publications with little decrease in quantity or quality, and is obviously taking thought for the post-emergency conditions that will arise, with a steadfast belief that she can and will outlast and outfight the dictators.

"The world used to look to Germany for a goodly proportion of new and basic information, such as appeared in the 'Archiv' and the 'Mitt. K.W. Institut.' One can hardly appraise the present quality and quantity, because the effective British blockade has kept many of the 1940 issues of these and other German journals piled up in Switzerland, waiting for a chance for shipment. Recently, some of the later issues have come out through Japan and Siberia. Most of these late samples are not very impressive. Only a few of the older authors are publishing, and some at least of what they do publish is picayune, like one report of laborious investigations which showed that the 'deformation between the 25th and the 35th hour' in a short time high temperature test gives no useful information as to long-time creep resistance, a matter that the rest of the metallurgical world knew long ago.

"It is interesting that despite the war, the abstract sections of both the English and the German periodicals carry *résumés* of the publications of the other country, showing respect for each other's technical knowledge. Indeed, we learn from the English abstracts something of the subject matter in the German articles in the journal issues held up by the blockade."

"Die Giesserei" is published fortnightly, and is the official organ of all the leading employers' and technical associations. The majority of the matter published is of purely acadamic interest, and has no bearing on current foundry practice. Moreover, there is every sign that much previously rejected material has been resuscitated in order to fill space. It is truthful to state that no information at all is given of current advances on German foundry technology or recent research. Many of the articles published are lifted from American, British, French, Belgian, and even Italian periodicals to fill space. A typical example is an article in the "Giesserei" for November 29 last, taken from a Belgian mining journal of 1937 dealing with copper ore deposits in the Belgian Congo, a subject of questionable interest to foundrymen, especially three years after original publication.

The abstracting service of this journal, which in the past was a good feature invariably showing evidence of systematic German thoroughness, has much depreciated owing to the delay in receiving foreign journals. So far as THE FOUNDRY TRADE JOURNAL is concerned, the abstracts terminated with the November 1, 1940, issue of "Giesserei," and covered our issue of April 25.

In recent times, a new section, "Foundry Practice Abroad," has been introduced, apparently as a space-filler, and includes a number of old articles from the foreign Press, mainly British and American. It is obvious that either there is no time available for German technicians to write articles or that there is a ban placed on this activity by the propaganda ministry or other authority. Thus the gagging of the Press extends to the technical section.

In this country the technical Press is still free to publish anything not detrimental to the war effort, and it is in this direction that we seek the co-operation of our readers. We ask them to submit articles direct to us, or to the Literary and Awards Committee of the Institute of British Foundrymen, so that the high standard which has obviously impressed American technologists may not merely be continued but thereby enhanced. The state of our engineering and metallurgical efficiency, as reflected in the technical Press, is regarded by intelligent readers abroad as an index of ability to achieve final victory.

Papers for the A.F.A. Convention

The 45th Annual Convention of the American Foundrymen's Association, to be held at the Hotel Pennsylvania, New York City, will include four sand shop course sessions and a "grey iron shop course."

The four grey iron shop course sessions will have as discussion leaders the following:—"Cupola Practice," by Donald J. Reese, International Nickel Company, Inc., New York; "Gating and Risering," by Elmer J. Carmody, C. C. Kawin Company, Chicago; "Electric Furnace Melting," by A. E. Rhoads, Detroit Electric Furnace Div., Kuhlman Electric Company, Bay City, Mich.; and "Casting defects and Remedies," by the A.F.A. Committee on Analysis of Casting Defects.

The 1941 lecture course, which will cover four sessions, will be on "Core Practices and Theories," with Mr. H. W. Dietert, Harry W. Dietert Company, Detroit, as the lecturer.

Partial List of Papers

The following is a partial list of tentative Papers, with their authors, for the many technical and research sessions:—

"Observations on Malleable Furnace Refractories," by J. A. Kayser, Laclede-Christy Clay Products Company, St. Louis.

"Natural Stone as a Cupola Refractory," by F. J. Wurscher, Acme Steel and Malleable Works, Buffalo.

"Graphitisation of Cementite in Cupola White Iron," by N. A. Ziegler, Crane Company, Chicago.

"The Velocity of Conversion of Austenite to Ferrite and Cementite," by H. A. Schwartz and M. K. Barnett, National Malleable & Steel Castings Company, Cleveland.

"Malleable Iron for the Defence Programme," by J. H. Lansing, Malleable Founders' Society, Cleveland.

"Flame Hardening of Malleable Iron," by Stephen Smith, Air Reduction Sales Company, New York City.

"Observations on the Duplexing of Malleable Iron," by G. A. Schumacher, Albion Malleable Iron Company, Albion, Mich.

"Gating and Risering for High-Pressure Iron Castings," by H. H. Judson, Goulds Pumps, Inc., Seneca Falls, N.Y.

"Effects of Moisture and Preheating on Cupola Blast," by J. T. Eash and R. E. Smith, International Nickel Company, Inc., Bayonne, N.J.

"Certain Aspects of Hydrogen in Cast Iron," by C. A. Zapffe, Battelle Memorial Institute, Columbus, Ohio.

"Effects of Pouring Temperatures on Mechanical Properties of Cast Iron," by V. A. Crosby, Climax Molybdenum Company, Detroit.

"Factors Influencing Graphitising Behaviour of Cast Iron," by S. C. Massari, Association of Manufacturers of Chilled Car Wheels, Chicago.

"The Undercooling of Grey Cast Iron," by Alfred Boyles and C. H. Lorig, Battelle Memorial Institute, Columbus, Ohio.

"Nickel-Molybdenum Cast Irons," by R. A. Flinn, Massachusetts Institute of Technology, Cambridge, Mass., and D. J. Reese, International Nickel Company, Inc., New York.

"Heat-Treatment of Cast Iron," by C. A. Nagler and R. L. Dowdell, University of Minnesota, Minneapolis, Minn.

"Fluidity of Cast Steels," by H. F. Taylor, Naval Research Laboratory, Anacostia, D.C.

"Mechanism of Pin-Hole Formation in Cast Steel," by C. E. Sims and C. A. Zapffe, Battelle Memorial Institute, Columbus, Ohio.

"Recent Developments in Producing Converter Cast Steel," by A. H. Jameson, Malleable Iron Fittings Company, Branford, Conn., and A. W. Gregg, Whiting Corporation, Harvey, Ill.

"Foundry Budgeting," by E. C. Bumke, Oliver Farm Equipment Company, South Bend, Ind.

"Welding Aluminium Castings," by F. T. McGuire, Notre Dame University, Notre Dame, Ind.

"Effects of Furnace Atmospheres in Non-Ferrous Melting," by J. M. Kelly, Westinghouse Electric & Manufacturing Company, E. Pittsburgh, Pa.

"Magnesium Alloy Foundry Practice," by M. E. Brooks and A. W. Winston, Dow Chemical Company, Midland, Mich.

"Aluminium - Copper - Magnesium-Zinc Castings," by L. W. Eastwood and L. W. Kempf, Aluminium Company of America, Cleveland.

"Some Properties of Foundry Sands at High Temperatures," by G. W. Ehrhart, Cornell University, Ithaca, N.Y.

"Progress Report on Investigation of High-Temperature Effects on Steel Sands," by J. R. Young, Cornell University, Ithaca, N.Y.

"Dry Sand Moulding Procedure for Heavy Castings," by W. A. Hambley, Allis-Chalmers Manufacturing Company, Milwaukee, Wis.

"Testing of Foundry Sands and Its Co-ordination with Moulding Procedure," by J. J. Boland, Griffin Wheel Company, Chicago.

"Reproducibility of Tests of Foundry Sands," by Stanton Walker, National Industrial Sand Association, Washington, D.C.

Observational Accuracy of Brinell Values with Cast Iron

To study the scattering obtained in the determination of Brinell numbers with a selected material, viz., a pearlitic cast iron, by different observers, measurements by a standard procedure were carried out at six German testing laboratories. The results of the tests are given by E. Pohl and H. Eisenwiener in Report No. 533 of the Materials sub-committee of the Verein deutscher Eisenhüttenleute in the "Archiv für das Eisenhüttenwesen." The standard test applied was that set out in DIN 1605, sheet 3, using a 10-mm. ball under a load of 3,000 kg. for 30 secs. In the hardness range from 120 to 180 Brinell units no connection could be found between the hardness value and the scattering of the results reported, nor between the personal equation of the observers and the apparatus used and the scattering. The range was therefore extended to 250 Brinell units, when a definite change in the scattering of the results with the hardness value and also with the texture of the samples became apparent. The scattering in the results diminished as the hardness increased, viz., from ± 13 Brinell units at 120 units average hardness to ± 5 and 6 units at 250 Brinell units. It was shown that the scattering in the hardness values with cast iron was not due to the ground mass, but to the quantity and state of formation of the graphite, although there was no relationship between the sum of the C and Si values or degree of saturation on the one hand and the scattering on the other.

Notes from the Branches

London.—A luncheon party is being organised by the Council to take place on Saturday, May 10, at the Dorchester Hotel, Park Lane, at 12.45 for 1 p.m. Ladies are to participate and members from the provinces will be welcome. Tickets, which are to cost 7s. 6d. each, can be obtained by writing to Mr. Barrington Hooper, C.B.E., the Branch-President, at 3, Amersham Road, High Wycombe, Bucks. Early application is essential.

Random Shots

Easter Monday came as a pleasant break from work for most foundrymen. To those who have no garden or allottment in which to put a good day's work, it possibly meant time for a little extra reading. It was a pleasant indulgence, for instance, to read the local weekly from cover to cover for once in a while, and to learn therein of the extraordinary "finds" which accumulate at the local library. It is only to be expected that a wastepaper basket set aside for bus tickets found in returned books would quickly fill up. It is even conceivable that an odd postal order might have been left in a book by a be-spectacled bookworm more engrossed in his treatise than in the money he had promised to send home to his aged mother. There is less excuse for the miscreant who makes a free gift of his national savings stamp book to the librarian, for it shows a lack of tenacity usually expected of ardent savers of money. But surely the most careless, and yet the most lovable of all, is the one who takes his book back leaving a table knife in it! He does not spoil his enjoyment of books by reading on the bus; nor does he hope to digest an odd paragraph whilst queuing up for his weekly savings stamps. He rightly reserves his treasure for his real leisure at home; in fact, he saves it for the happiest half hour of the day, when, having finished with the worries of the day's work, he sits down in front of a cosy fire to a comfortable tea, replete with hot muffins and a large pot of steaming tea against which to prop the latest thriller. He is, of course, a bachelor, and indeed, what married man does not secretly regret that solitary teapot supporting the inevitable novel when he exchanges it for the family table where such indulgencies are not to be endured?

On such leisurely occasions the advertisements have their entertaining side. Who would expect, for instance, that an R.A.F. officer would want to possess an "unlucky mascot or bringer of bad luck?" No doubt he wishes to deride all belief in superstition, but does he not thereby show himself to be more superstitious than the devotees of lucky mascots themselves? for by carrying an omen of ill-luck he expects it to bring him good luck.

* * *

It is not now the fashion amongst the younger set to go out "courting" as in the good old days. They just go "fire-watching." Parents, however, must not be misled by this simple ruse, for the new game does not differ from the old in its essentials. It always was and still is just a matter of larking about with flames.

* * *

The best metallurgical crossword clue of the week appeared in yesterday's "Times." The clue was "Metal for the fight," and the answer, "Scrap iron."

* * *

This week's quiz:—

(*a*) What is an Easterling?

(*b*) A tourniquet is: A croquet match; a medieval festival; a bit of first aid equipment; a Norwegian bird.

(*c*) What do the following stand for: G.O.B.; B.S.I.; B.O.T.; D.T.D.; C.R.C.A.; B.N.F.N.R.A.?

* * *

Answers to last week's quiz:—

(*a*) Institute of British Foundrymen; British Industries Fair; Federation of British Industries; a lie.

(*b*) An object of interest to astronomers.

(*c*) To the heirs of the Duke of Wellington.

(*d*) A group of islands in the Ægean Sea.

(*e*) A system of currency.

(*f*) See Mr. McRae Smith's article in the issue of March 27.

"Marksman."

Unsoundness in Gravity Die-Cast Silicon-Aluminium Alloy Pistons*

By R. T. PARKER, B.Sc., A.R.S.M.

Introduction

The unsoundness of castings has provided many investigators with a field of research ever since aluminium alloys have been used on a commercial scale. The subject has many aspects, but the unsoundness is caused mainly by two natural characteristics of aluminium and its alloys, a decreased solubility of gas in the solid as compared with the liquid state, and the shrinkage which accompanies the change from liquid to solid.

In the present Paper an investigation of an industrial problem is described. Trouble had been experienced in the gravity die-casting of small internal-combustion-engine pistons in "Lo-Ex" alloy, a well-known alloy for this class of work, containing essentially 12 per cent. silicon with certain other alloying additions.

The difficulty that had been encountered was the occurrence of unsoundness in the skirt of the piston—not at the junction of the piston wall with the runner or riser (where shrinkage might be expected), but below the gudgeon-pin bosses. The cavities were often very small and required the use of a hand lens for their detection. The unsoundness was encountered when pistons were machined with a diamond tool under certain conditions. The disadvantage of the presence of the unsoundness lay in the danger of damaging or deranging the diamond tool, besides giving an unpleasing surface to the finished piston. A feature of the problem was that unsoundness, when it occurred, appeared to be common to the whole of the output of the foundry producing the pistons. Such an observation naturally suggests that variations in the degree of gaseous contamination might be at the root of the problem, but, since it was known that attention to this aspect had not resulted in complete solution of the problem, work was undertaken to investigate several other factors.

Process of Manufacture of the Pistons

The alloy from which the pistons were cast was prepared from virgin materials in coke-fired reverberatory furnaces of approximately 9 tons capacity. This metal was pigged and sent to the foundry for remelting in smaller batches, the delay between pigging and remelting varying from a few days to some weeks. The alloy was stored under cover in the interval. In the foundry, charges of 50 per cent. pig and 50 per cent. scrap (runners and risers, &c.) were melted in quarter-ton oil-fired tilting crucible furnaces, twelve such charges being handled in a day in each furnace. The metal was transferred from the tilting furnaces in carrying pots of about 50 lbs. capacity to maintaining pots holding 150 lbs. These latter were also oil-fired.

Two casters worked from each maintaining pot, their rate of production being 30 to 40 pistons each per hr.

Some details of the pistons are as follow:

Diameter, as cast ..	72 mm.
Diameter, after machining	68 mm.
Height, as cast	80 mm.
Thickness of skirt, as cast	4 mm.
Thickness of skirt, after machining	about 2 mm.
Weight of piston, as cast..	about 350 grm.

The die assembly consisted of an outer die and a core of several sections, the piston being cast with its crown down. A runner and a riser of similar shape were disposed on either side of the piston, at the two positions on the surface midway between the gudgeon-pin holes. The gate extended approximately the full depth of the piston wall. The die was cooled with circulating water, and cooling of the core was effected by dipping the sections in a water sump. A protective and heat-insulating wash was applied as the occasion warranted to assist in varying the process of cooling of the casting. Metal was ladled by hand from the maintaining pot, and the casting removed from the die as soon as possible consistent with safety.

The temperature of the metal in the maintaining pot was controlled by periodic checking with portable instruments, but a considerable degree of control was exercised by the casters themselves, through adjustment of the rate of heating of the pot or by the addition of cold metal. One piston from each hour's output per man was machined for test purposes, the piston being judged primarily by its surface appearance with the aid of a lens. Test pistons were machined using first a steel and finally a

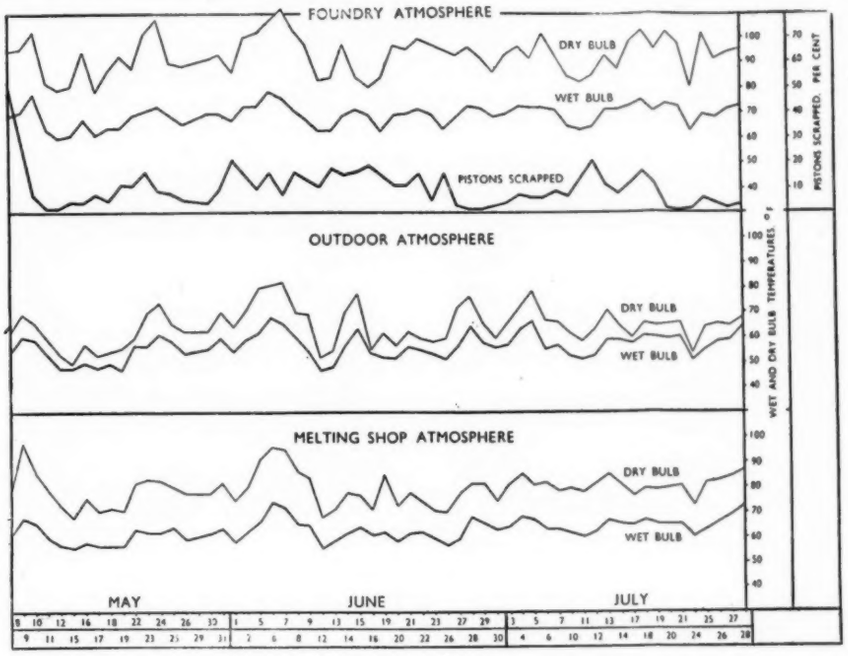


Fig. 1.—Influence of Atmospheric Conditions on Scrap Production.

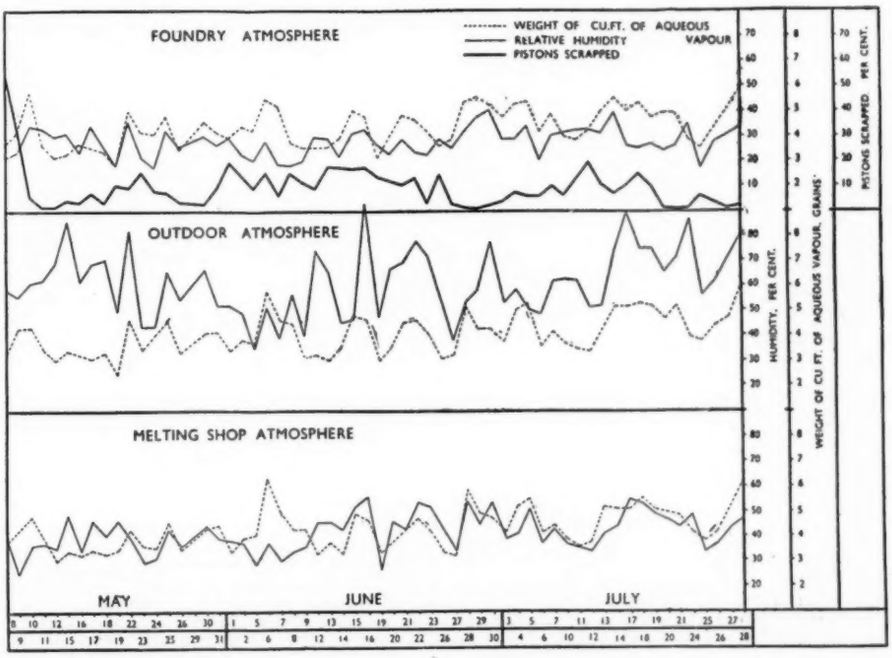


Fig. 2.—Influence of Atmospheric Conditions on Scrap Production.

* A paper prepared for presentation to the Institute of Metals; the author is Research Metallurgist, Research and Development Dept., Northern Aluminium Company, Ltd., Banbury, Oxon.

diamond tool, one cut with each usually being sufficient. The quality of the cut made by the diamond varied with the state and setting of the tool.

Examination of Typical Pistons

In order to compare good and bad pistons, some which had been passed by the machining test and others which had been rejected were sectioned and examined under the microscope. The results were, in brief:—

No. 363. "Unsound." Many small cavities in the skirt and some larger ones in thicker sections. All appeared irregular in outline.

No. 365. "Sound." Actually not as well machined as some of the other pistons examined. Holes near the surface burred over by the tool. Also one area of unsoundness identified as an oxide skin in the skirt.

No. 375. "Very good." Contained some unsoundness in the skirt remote from the machined surface. Structure fine.

No. 377. "Unsound." Contained not much more unsoundness than No. 375, but disposed at random through the cross-section of the skirt. Structure coarse.

No. 408. Piston prepared from metal carefully "degassed" by commercial process. Showed some general fine unsoundness and a fine structure.

From the foregoing examination, it was decided that the following factors would repay investigation:—

(1) The influence of atmospheric conditions, since the variation in soundness might be due to gas contamination.

(2) Variation in the machining of test specimens, since it could be seen that differences in cut might hide cavities and make an unsound piston appear satisfactory.

(3) Effect of variation of temperature of the die-body and core, since it appeared that unsoundness might be displaced through the thickness of the skirt under certain conditions. This, while not eliminating the unsoundness, would explain a variation in appearance otherwise unaccountable.

(4) Effect of the quality of the metal as regards gas content, with particular reference to die-assembly temperatures.

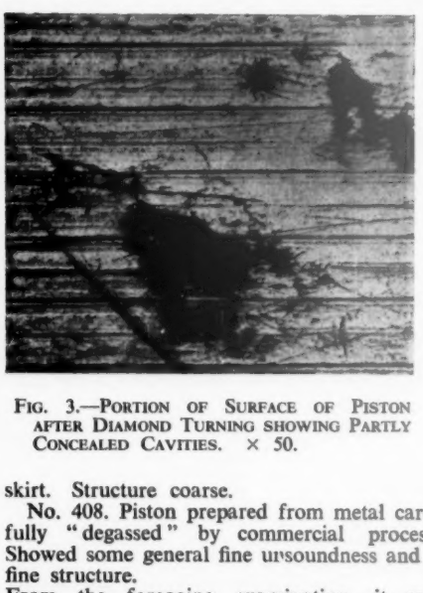


Fig. 3.—Portion of Surface of Piston after Diamond Turning showing Partly Concealed Cavities. × 50.

Effect of Atmospheric Conditions

To investigate the effect of atmospheric conditions, daily readings of wet- and dry-bulb thermometers were taken from early in May, 1939, until the end of July, 1939, at the works in which the pistons were being produced. From these readings, values were calculated for the relative humidity and weight of a cub. ft. of aqueous vapour, and these readings were correlated with the daily percentage of scrapped pistons.

The wet- and dry-bulb temperatures were taken in three places:—(1) In the foundry itself, in a central position; (2) in the open air outside the foundry, and (3) in the melting room (where the alloy was pigged for subsequent use in the foundry) between the lines of ingot moulds used for pigging.

The instrument used was a whirling hygrometer, which usually gave a steady reading after being rapidly rotated. The results have been plotted in the form of graphs (Figs. 1 and 2), in which working days only have been used on the time scale.

Fig. 1 shows the wet- and dry-bulb temperatures for the three positions, with the addition to the foundry temperatures curves of the curve showing percentage of scrap. Broadly speaking, the percentage of scrap progressed from one low value on May 10 to another at June 30, with an intermediate low value about May 31. This corresponds very roughly with the dry-bulb, or actual, temperatures in the foundry. After June 30, the percentage of scrap again rose and fell to a minimum about July 24, but the relationship with temperature is here more obscure.

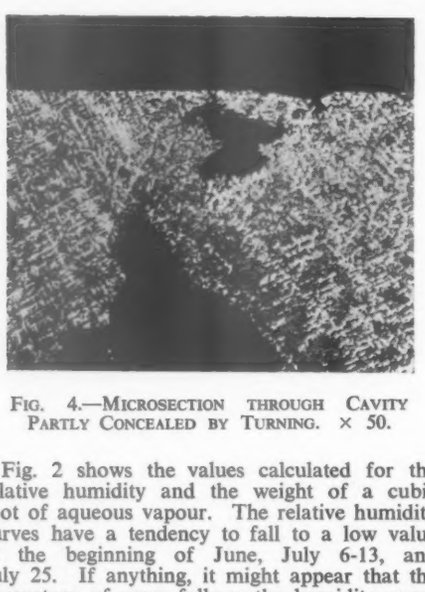


Fig. 4.—Microsection through Cavity Partly Concealed by Turning. × 50.

Fig. 2 shows the values calculated for the relative humidity and the weight of a cubic foot of aqueous vapour. The relative humidity curves have a tendency to fall to a low value at the beginning of June, July 6-13, and July 25. If anything, it might appear that the percentage of scrap follows the humidity curve 14 days later. On examining the curves more closely, it will be seen that there are several cases in which sudden changes in humidity are accompanied by sudden changes in the percentage of scrap. Take, for example, the peaks of June 5-6-7, June 12-13-14, June 15-16-19, and July 6-7-10 on the foundry atmosphere curve.

The correlation of atmospheric conditions with the percentage of scrap pistons is difficult, since there are many factors which obscure the results. To establish the relationship quite definitely, the unpractical procedure of casting pistons without any attempt to improve the return of good pistons would be most effective. As it is, there is a natural reaction to do everything possible when the percentage of scrap rises, so that an increase in humidity under such conditions may be accompanied by a slight rise and then a rapid fall in the percentage of pistons scrapped.

Variation in Quality of Machining of Pistons

A piston from a batch that had been rejected by the machining test which has been described, was passed to a customer for comment. After re-machining by the customer the piston had a good surface when examined visually, which would suggest that it was perfectly satisfactory. Examination of the piston with a lens, however, showed that there were many small discontinuities in the surface, recognisable as cavities partly hidden by flowed metal. A photograph of a portion of the surface of the piston is given in Fig. 3.

Following upon this, an X-ray examination was made of portions of the piston, which showed that the sample was quite as unsound as some pistons previously examined and known to be unsatisfactory. The unsoundness was again particularly pronounced in the skirt below the gudgeon-pin holes.

The examination of microsections from several places in the unsound region showed serious unsoundness just underneath the surface. One section which cut through a cavity lying just beneath the machined surface illustrated the effect of machining in minimising the extent of unsoundness in this particular case. Fig. 4 shows a typical section.

The examination of the above piston confirmed the impression that the machining test was one that could be used either to reveal unsoundness or to disguise it, according to the technique adopted. With this specimen it was noted that, while no great amount of flow of the surface had been effected where that surface was sound, elsewhere cavities had been hidden by the collapsing of material around them. A further interesting point was that the surfaces of some pistons machined in testing showed quite clearly the microstructure typical of the alloy—which was not the case with the piston under consideration. It will be seen that variations in machining technique might very well explain a periodicity in the scrapping of pistons. In subsequent work a close watch was kept upon the standard of the machining used in examining test pistons.

(To be continued.)

"PROTECTED" WORK

NEW SCHEDULE OF RESERVED OCCUPATIONS

A new schedule of reserved occupations has been compiled by the Ministry of Labour and National Service. Copies can be obtained from the Stationery Office, price 1s. The new schedule has a double object—of increasing the number of men in the Fighting Forces and increasing the number of men engaged on civilian work of national importance. A man under the new schedule losing his present reservation can serve the country either by joining the Forces or by transfering to reserved work if he gets the chance.

The new schedule includes an explanatory memorandum, a list of reserved occupations (Part I), a list of the classes of establishments which the Minister is prepared in the first instance to consider for admission to the Register of Protected Establishments (Part II), exceptions from the operation of the schedule and special arrangements for men with certain qualifications and certain classes of students (Part III), occupations in which women only are reserved (Part IV), and an index to Part I of the schedule.

The raising of the ages in the schedule is spread over three stages. Men de-reserved from stage A (April 1) will not be required to join their units before June 1; those de-reserved at stage B will not, as a rule, join up before the middle of July; in stage C men de-reserved will not be conscripted before October 1. Examples:—

Metal manufacture: A 18; C 23, 25.

Coal mining: A 30. Iron ore and ironstone: A 18, 21, 23, 30. Quarrying and open pit, clay hole, etc.: A 30; B 21; C 25, 35.

Speedy Furnace Relining

Unusual speed was achieved in relining a blast furnace by the Wisconsin Steel Company, Chicago. No. 2 stack was blown out on December 1 and blown in on January 30, completely relined and rehabilitated. The stack has a capacity of 600 tons daily. Usually the work thus completed in 60 days requires 90 days, says "Blast Furnace and Steel Plant"

Chromium-Molybdenum Cast Steels*

IMPROVED PHYSICAL PROPERTIES

Cast steels, alloyed with chromium and molybdenum, develop a good combination of properties, and are suitable for a wide variety of applications. In the various carbon ranges, chromium-molybdenum cast steels are used for brackets, crankshafts, gears, locomotive parts, rolling mill rolls, derrick hooks, and heavily stressed machine parts. The use of this material for dies, muller tyres, crusher hammers, jaws and plates, roll shells, dipper teeth and other parts subjected to wear and abrasion is well established.

Carbon, chromium, and molybdenum contents are varied according to service conditions. The usual range for structural parts is 0.25 to 0.40 per cent. carbon; 0.60 to 1.00 per cent. chromium; 0.25 to 0.40 per cent. molybdenum. For highly abrasive service, fairly high carbon and high alloy contents are generally favoured since these steels can be satisfactorily hardened to 500 Brinell by air treatment. For heavy-duty cast dies, and parts subjected to impact, a higher molybdenum content is advantageous. In steels containing 0.50 to 0.70 per cent. molybdenum, the casting is usually double-normalised and tempered to 400-500 Brinell.

The physical properties of several chromium-molybdenum cast steels are shown in Table I.

Table I.—*Physical Properties of Cr-Mo Cast Steel.*

Composition.			Heat treatment. Deg. C.	Physical properties.					
C. Per cent.	Cr. Per cent.	Mo. Per cent.		T.S. Tons per sq. in.	Y.P. Tons per sq. in.	El. per cent. on 2 in.	R.A. Per cent.	B.H.N.	Izod imp. Ft.-lb.
0.25	0.75	0.29	N. 925, T. 675	38.5	24.0	23.4	39.8	—	—
0.31	0.57	0.22	N. 900, T. 595	46.6	31.9	20.0	35.0	207	22.0
0.31	0.57	0.22	N. 900, T. 650	44.6	30.9	22.5	46.6	196	30.2
0.31	0.57	0.22	N. 900, T. 700	40.6	28.7	27.0	54.7	179	31.7
0.33	0.85	0.38	N. 900, T. 650	39.7	26.8	24.0	43.0	—	—
0.36	0.76	0.35	N. 925, T. 650	43.8	27.1	12.5	31.6	—	—
0.44	0.75	0.30	N. 925, T. 675	50.2	27.9	16.6	25.8	—	—
0.25	0.75	0.29	O.Q. 870, T. 675	52.1	33.2	14.0	31.8	—	—
0.27	1.00	0.50	O.Q. 800, T. 565	66.1	61.4	9.2	27.8	—	—
0.27	1.00	0.50	O.Q. 800, T. 620	56.9	49.8	16.0	42.6	—	—
0.27	1.00	0.50	O.Q. 800, T. 675	47.8	38.2	20.0	46.7	—	—
0.35	0.88	0.45	O.Q. 845, T. 605	90.1	87.0	5.0	13.0	444	—
0.35	0.88	0.45	O.Q. 845, T. 700	53.5	45.4	18.5	41.3	229	—
0.36	0.76	0.35	O.Q. 870, T. 675	49.8	38.3	17.2	35.7	—	—
0.44	0.75	0.30	O.Q. 870, T. 675	54.2	43.8	14.8	27.6	—	—

Table II.—*Properties of Heavy Sectioned Cr-Mo Steels.*

Tempered at deg. C.	Physical properties.					
	T.S. Tons per sq. in.	Y.P. Tons per sq. in.	El. per cent. on 2 in.	R.A. per cent.	B.H.N.	Izod. imp. Ft.-lb.
1-in. section.						
600	47.6	31.9	20.0	35.0	207	**22.0**
650	44.0	30.9	22.5	46.6	196	**30.2**
700	40.6	28.7	27.0	54.7	179	**31.7**
2-in. section (edge).						
600	42.8	27.5	17.0	24.4	187	24.9
650	41.7	26.5	16.0	21.6	179	25.8
700	39.4	24.6	21.5	33.0	170	24.7
2-in. section (centre).						
600	42.4	26.5	14.0	20.6	187	23.5
650	41.9	26.0	16.0	19.5	179	22.6
700	39.0	24.9	19.3	27.2	170	22.1

In heavier sections, chromium-molybdenum steels develop properties comparable with those shown in Table II. In this case the heat was cast in 1 and 2 in. sections. The steel was normalised from 900 deg. C., and tempered in full sized section.

Analysis:—C, 0.31; Mn, 0.69; Si, 0.40; Cr, 0.57; Mo, 0.22 per cent.

Elevated Temperature Properties

As in other molybdenum steels, chromium-molybdenum steel castings retain high strength at elevated temperatures. Table III gives the quick tensile properties of a chromium-molybdenum steel of the following analysis:—C, 0.17; Mn, 0.46; Si, 0.20; Cr, 1.06, and Mo, 0.51 per cent.

Before testing, the steel was annealed at 900 deg. C., reheated to 940 deg. C., and held at temperature from 3 to 4 hrs. It was furnace cooled to 550 deg. C. and air-cooled to room temperature. It was then tempered at 650 deg. C.

Table III.—*Quick Tensile Properties at Elevated Temperatures.*

Testing temp. Deg. C.	T.S. Tons per sq. in.	Y.P. Tons per sq. in.	El. per cent. on 2 in.	R.A. per cent.
20	32.0	16.7	28.0	51.2
300	30.4	11.9	21.1	42.9
350	30.4	11.4	21.7	42.8
400	29.5	11.3	20.3	33.8
450	28.3	11.1	26.5	55.7
500	26.8	11.1	25.2	58.9

1.50 per cent. Chromium—0.50 per cent. Molybdenum Cast Steel

This steel has been developed for high temperature service. Normalised and tempered, it develops tensile strengths from 33 to 50 tons per sq. in. The following average room temperature physical properties were obtained from a total of 67 heats: Tensile strength, 45 tons per sq. in.; yield point, 28.2 tons per sq. in.; elongation (in 2 in.), 24.0 per cent., and reduction of area, 47.9 per cent. The steel was normalised from 900 deg. C. and tempered 620 to 662 deg. C. The composition was: C, 0.20 to 0.30; Mn, 0.50 to 0.70; Si, 0.25 to 0.45; Cr, 1.25 to 1.75, and Mo, 0.45 to 0.65 per cent.

4 to 6 per cent. Cr—0.50 per cent. Mo Cast Steel

At the present time, the largest field of application for 4 to 6 per cent. chromium, 0.50 per cent. molybdenum steel is in the oil industry, where the physical property requirements for refinery service are of the order of 49.5 tons per sq. in. tensile strength, 33.5 tons per sq. in. yield point, 18 per cent. elongation in 2 in., and 30 per cent. reduction of area. In most specifications, a carbon content as high as 0.35 per cent. is permissible, although the usual range is 0.15 to 0.30 per cent. To obtain the best combination of properties, carbon is usually held at 0.20 per cent.

Since the steel is air-hardening, slow cooling with freedom in the moulds and a preliminary heat-treatment are advisable before removing gates and risers. This preliminary treatment is usually a normalising operation from above 954 deg. C. and is followed by tempering at about 650 deg. C. Annealing, followed by slow cooling, is also a satisfactory method of preparing the casting for machine work.

Hairline cracks which may occur due to the flame cutting of gates and risers can be avoided by preheating the work to 480 deg. C. Severe grinding should be avoided.

If the structure be not sufficiently refined by the normalising and tempering treatment, a second treatment may be used—namely, heat to 900 to 925 deg. C. and soak for a period somewhat longer than is usually employed for carbon steels of the same section. Cool in still air and temper at 655 to 675 deg. C. With such a high tempering temperature, internal stresses in the steel are minimised.

As in other molybdenum steels, resistance to creep is an outstanding property of this steel. Corrosion resistance is distinctly better than that of plain carbon steels.

In the oil industry, chromium-molybdenum cast steel has found an almost endless number of applications, including return bends, flanges, oil pump impellers, flow line headers, pipe fittings, oil pump diffuser rings, plugs, valve bodies, oil-pump casings, yokes, valve gear and condenser fittings. It has been reported that chromium-molybdenum cast steel gives as much as six times the life of plain carbon steel castings in service at temperatures used in refineries. The composition usually employed is:—C, 0.15 to 0.30; Mn, 0.60 to 0.85; Si, 0.40 to 0.60 per cent.; P, 0.05 (max.); S, 0.05 (max.); Cr, 4.50 to 6.50, and Mo, 0.40 to 0.65 per cent.

Representative physical properties at room temperature after normalising at 955 deg. C., then at 900 deg. C., and tempering at 650 deg. C. are as follow: Tensile strength, 49.5 to 53 tons per sq. in.; yield point, 33.5 to 38 tons per sq. in.; elongation, in 2 in., 16 to 20 per cent.; reduction of area, 30 to 55 per cent., and Brinell hardness, 210 to 250.

Table IV.—*Coefficient of Linear Expansion of 4 to 6 Cr 0.50 Mo Steel.*

Temp. range. Deg. C.	Coefficient. In./in./deg. C.
20 to 150	11.17×10^{-6}
150 to 315	13.13×10^{-6}
315 to 427	14.68×10^{-6}
427 to 538	16.27×10^{-6}
538 to 650	17.20×10^{-6}

The coefficient of linear expansion of 4 to 6 per cent. chromium, 0.50 per cent. molybdenum steel, is given in Table IV.

Corrosion Resistance

Table V gives the results of tests to determine the comparative corrosion resistance of several types of cast steels. All specimens were exposed to petroleum vapour under 175 lbs. pressure for 1,000 hrs. at 345 deg. C.

* Compiled from data issued by the Climax Molybdenum Company of Europe, Limited.

Welding

This type of steel can be welded by either the electric arc or the acetylene method. With either method it is essential that welding rods of the same composition be used, and further, a coated rod should be used for arc welding. It is recommended that the weld metal not be puddled, as this practice has a tendency to cause porosity and excessive oxidation. All castings of this steel should be heat-treated after welding. The recommended treatment is as follows:—Heat to 925 deg. C., air cool, and temper at 650 deg. C.

After welding in the field, it is frequently impossible to heat-treat as previously suggested. In such cases a stress relief anneal will generally suffice. This can be accomplished by heating the areas adjacent to the weld with the acetylene torch to a temperature of approximately 650 deg. C. This temperature should not be exceeded.

Table V.—*Comparative Corrosion Tests in Petroleum Vapour.*

Material.	Weight loss. Mg. per sq. in.
Cast carbon steel	196.0
0.70 per cent. Cr, 2 per cent. Ni cast steel	153.0
5 per cent. Cr. seamless tubing	99.2
5 per cent. Cr, 1 per cent. W cast steel	61.5
5 per cent. Cr, 0.50 per cent. Mo cast steel	47.0
12 per cent. Cr steel	6.4
18 per cent. Cr, 8 per cent. Ni steel	2.1

EXCESS PROFITS TAX

CONCESSION TO INDUSTRY

Under the fourth war budget, presented in the House of Commons last week by Sir Kingsley Wood, Excess Profits Tax is maintained at 100 per cent., but 20 per cent. is to be refunded after the war. A special allowance will be given to concerns engaged in producing metals or oils specially required for munitions. Provision is to be made for adjusting the taxation law for businesses subjected to the Government's concentration of production schemes. Where increased profits arise from the extension and development of business involving new capital, the increase is to be computed on the total capital employed. Interest paid on borrowed capital will no longer be allowed as a deduction in computing profits.

The Government's policy of stabilising prices to prevent increased cost of living is to be extended, and will include coal, gas and electricity. The question of how far the Exchequer might help in averting further increases in railway fares and charges is being examined by the Chancellor. The bonus share ban is to be continued, and any necessary steps are to be taken to prevent profits being dissipated in dividends.

Announcing his E.P.T. proposals, the Chancellor said that in the case of concerns engaged in producing metals and oils urgently required for munitions of war, he proposed to give an allowance by way of recompense for the loss of future profit entailed in the using-up of the assets in the present national emergency. Industry in general would still be subject to the 100 per cent. rate of tax, and the whole of the excess profit would continue to be paid over to the Exchequer. He proposed, however, to treat part of the produce of the 100 per cent. rate as a reserve to be made available to industry at the end of the war for the purposes of reconstruction. His proposal was that at the end of the war, subject to such conditions as Parliament might then determine, 20 per cent. of the net 100 per cent. tax should be refunded. The object was to assist industry to undertake the essential task of reconstruction and readjustment, and to re-absorb the mass of the nation as quickly as possible into profitable peacetime employment. The amount of 20 per cent. Excess Profits Tax repaid would fall to be treated as trading receipts, and thus come under the charge to income-tax, so that the fund actually available to industry from this concession would be the 20 per cent. less whatever income-tax was due.

Tumble-Burnishing Die Castings*

By C. R. Maxon, New Jersey Zinc Company.

Since the cost of polishing and buffing die-castings to be plated constitutes a considerable part of total finishing cost, any less-expensive substitute is deserving of study. Many plating plants are devoted almost exclusively to plating of die-castings, usually of zinc alloy, and not a few of these have attained good results from tumble-burnishing on certain types and grades of work.

Although the quality of finish from tumble-burnishing is not quite equal to that resulting from polishing and buffing, it is adequate for some products, and results in marked savings in cost, especially on small die-castings—the only type adapted for burnishing by tumbling. Under the best of conditions, the results so closely approximate polishing and buffing that only experts would normally observe such differences as can be detected.

Some platers prefer wet burnishing, which is done in an alkaline solution containing a good burnishing soap and steel balls of such size as to reach all exposed surfaces of the castings being handled. Others employ a form of dry burnishing, using wood-lined barrels in which, besides the castings, various "cutting down" and polishing ingredients are employed.

The wet process may be regarded as somewhat more "messy" and involves, of course, the use of water for which drains must be provided, but it seems to be somewhat simpler and to require, perhaps, rather less attention and skill on the part of those supervising the work. The dry process has certain advantages in cleanliness, but presents the disadvantage that small holes may become clogged with the materials used and perhaps involve some extra work in their removal. On the other hand, the best burnishing results which have come to the writer's notice have been secured by dry burnishing.

In either the wet or dry process there are several variable factors that have a bearing on the results, and considerable experimental work may be necessary to ensure getting optimum results or even such results as will pass muster. Among these are:—Size, shape and original finish of castings to be treated; type and proportion of ingredients used, both in respect to each other and to the quantity of castings per batch; size of tumbling barrel and the speed at which it is turned; total time of burnishing and, with the dry process, at least, the relative time in different "cutting down" and finish-burnishing materials.

In wet burnishing, about the same solution is used for the entire job and for many different parts, but the size of balls and the length of time are the chief variables, these depending on the natural surface quality and nature of the casting and the quality of finish required. In dry burnishing, a given shop is likely to employ about the same burnishing compounds for different sizes and shapes of castings, but may vary the proportions of ingredients, the length of time in each and the total time of treatment. Sometimes more and sometimes less abrasive is used, and the effectiveness of a given mix varies with its length of use.

As the cost of wet burnishing solutions is low, they are commonly thrown away when the barrel is emptied, but, of course, steel balls are used repeatedly. A simple rinsing makes wet-burnished castings ready for normal cleaning and plating procedures. With dry burnishing, of course, the castings must be separated from all solid matter, either by sifting or in subsequent cleaning, and this is usually not difficult unless

(*Continued at foot of next column.*)

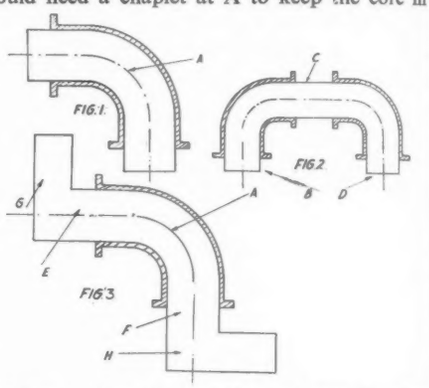
* From "Metals and Alloys."

Making Elbow Pipes Without Chaplets

By "Tramp."

A Stoke-on-Trent reader specifically asked the writer to outline a method of making an elbow pipe without the use of stops or chaplets, and the following article has been prepared.

Pipes of odd length and shape as well as various types of pipe fittings are often called for from jobbing shops, and their production is a very interesting phase of foundry work, especially for the better class jobs which have to withstand hydraulic pressure tests. Castings in the latter class have often to be made without the aid of studs or chaplets to retain the core in position during pouring as their use would invariably cause porosity, a defect that would not be revealed until the pressure test and a considerable amount of machining had been carried out on the casting. Fig. 1 is a section of a typical elbow of medium dimensions which if made with core prints and core as shown would need a chaplet at A to keep the core in



position. If a fair number of castings were required two patterns linked together as Fig. 2 would be ideal, as the core being made in one piece would be retained in position by the three supports B, C and D. Often, however, castings from jobbing shops are only "one off" or at most a few at remote intervals, so a double pattern would be too expensive. An alternative is to print the pattern and make the core in such a manner that the core is self-balancing—thus eliminating chaplets from the mould. Fig. 3 is a section of such a pattern. The core prints E and F are the shape of the holes in the pipe—which may or may not be circular—but beyond E and F, G and H are large rectangular shaped prints of sufficient size to counteract the tendency of the portion A to tip. Cores for small pipes could be made in a suitable core-box of sea-sand and reinforced by wires, while larger cores would necessitate a stiff cast-iron core grid and the core could be made in the mould by "thicknessing." This consists in lining the mould with pieces of clay, the thickness of the required casting and building the core *in situ*. For very large elbow pipes skeleton patterns are used from which both the mould and the core are made, and the core grids are designed in such a manner as to retain the core in correct position during casting without the aid of chaplets.

(*Continued from previous column.*)

granules of the materials used become wedged in small holes.

Naturally, the smoother the castings treated, the easier and faster is burnishing done. As the flash is rather tough and not very easily broken away by burnishing action, and as "whiskers" also make burnishing difficult, the flash should be sheared as cleanly as possible and without leaving a ridge where the die parting comes if the ridge is objectionable in the finished product.

Aluminium Castings for Aircraft*

THE TYPES, PROPERTIES AND USES OF COMMERCIAL SAND CASTING ALLOYS EMPLOYED IN AIRCRAFT STRUCTURES

By NORMAN E. WOLDMAN, Ph.D.

The relative densities of aluminium and other aircraft metals and alloys are shown in Table I. It will be observed that aluminium is 50 per cent. heavier than magnesium, but is about one-third of the weight of iron and steel, and less than one-third of the weight of copper alloys.

A true appreciation of the characteristics of aluminium alloys and their suitability for aircraft structures, requiring maximum strength and endurance with a minimum weight, is obtained when their properties are compared with those of other commercial metals. Table II shows the comparative properties of a heat-treated cast aluminium alloy *versus* other metals for equal volume relations; while Table III shows the comparative properties of a heat-treated cast aluminium alloy *versus* other metals for equal weight relations.

Types of Castings

Aluminium casting alloys may be classed in four groups, as follow:—(1) Sand castings; (2) permanent mould castings; (3) die castings; and (4) plaster mould castings.

The sand casting and permanent mould casting group of alloys may be further sub-divided into non-heat-treatable and heat-treatable alloys; that is, one in which the improvement in properties is accomplished by alloying alone, and the other in which heat-treatment processes are used to enhance further the mechanical properties. The type of casting process which is used will depend upon several factors. For large or for intricate cored castings, the use of sand moulds is necessary. Because a metal mould or steel die is required, the use of die and permanent mould castings can be considered only where a sufficiently large number of castings of the same pattern will be used to justify the cost of the mould or die. The die-casting process is particularly adapted to the quantity production of relatively small castings in which close dimensional tolerances are required and the cost of finishing must be held to a minimum. The dimensional tolerances of permanent mould castings are intermediate between those of sand castings and those of die castings, and the surface finish approaches that of die castings. Plaster mould castings are similar to sand castings, but with smoother surface and closer tolerances. Certain alloys, heat-treatable and non-heat-treatable types, can be cast in plaster moulds.

TABLE I.—*Relative Densities of Various Commercial Metals.*

	Specific gravity	Lb. per cub. in.
Magnesium	1.8	0.065
Aluminium	2.7	0.101
Zinc	7.1	0.256
Cast iron	7.2	0.260
Steel	7.9	0.285
Stainless steel	7.92	0.286
Brass	8.5	0.307
Bronze	8.8	0.318
Monel metal	8.9	0.323
Copper	8.9	0.323

Casting Alloys

By the addition of various alloying elements or "hardeners" to aluminium, not only its tensile strength, but casting properties as well, are improved. By alloying alone, strengths almost double that of commercially pure aluminium are obtained, and the increase in strength is gained at a sacrifice of most of the ductility of the parent metal. The elements commonly used as hardeners are copper, silicon, magnesium, zinc, manganese, nickel and iron. The properties of the alloys vary, depending within certain limits upon the element or elements which are added and upon the percentages used.

Castings permit better distribution of metal to resist shock than do built-up wrought structures. Castings have better properties than many wrought alloys at elevated temperatures.

Silicon-Aluminium Alloys

Silicon-aluminium alloys are very fluid, have excellent casting characteristics, and are thus used for thin-wall and complicated castings. The castings are very dense and leak-proof. They have a lower specific gravity than other aluminium alloys and have good corrosion resistance. However, silicon-aluminium alloys have inferior machining characteristics because of the tendency of tools to drag the surface. They have lower yield strength-tensile strength ratio than copper-aluminium alloys, but in many cases they have higher impact resistance and ductility. These binary silicon-aluminium alloys are not suitable for high-temperature applications.

TABLE II.—*Comparative Properties of a Heat-Treated Aluminium Alloy vs. Other Metals —Equal Volume Ratios.*

	Relative weight.	M.S. Tons per sq. in.	E. Per cent.	Fatigue endurance limit in bending.
Mild steel	4.4	26.8	30	30,000
Alloy steel	4.4	44.7	20	50,000
Aluminium alloy, cast, heat treated (Alcoa 220-T4)	1.6	20.1	14	7,000
Aluminium alloy, wrought, heat treated (Alcoa 24 ST)	1.6	30.4	20	18,000
Magnesium alloy, cast, heat treated (Dowmetal-H)	1.0	14.7	10	9,000
Magnesium alloy, wrought, heat treated (Dowmetal-E)	1.0	18.7	12	14,000

Copper-Aluminium Alloys

Copper-aluminium alloys respond to heat-treatment and, therefore, have high strength and hardness. These alloys are not used for very thin sections and the castings are not as pressure tight as castings of the silicon-aluminium alloys. They possess a desirable combination of good casting characteristics and good machinability.

Copper-Silicon-Aluminium Alloys

Copper and silicon, when added together to aluminium, make the alloys particularly suitable for permanent mould and die-casting applications because of their excellent casting characteristics. They can be used for large and intricate sand castings. Their limitations are two-fold, namely, they are not as resistant to impact as the simple heat-treated binary copper-aluminium alloys, and they are less corrosion resistant than the simple silicon-aluminium alloys. However, these ternary alloys have a wide application, since they respond well to heat-treatment, producing excellent mechanical properties. They are leak-proof, pressure-tight and retain strength up to 200 deg. C. They can be used, nevertheless, above 200 deg. C. This group of alloys attempts to combine the casting characteristics of the silicon-aluminium alloys with the mechanical properties and machining characteristics of the copper-aluminium alloys.

Magnesium-Aluminium Alloys

Magnesium-aluminium alloys are difficult to cast, but they have maximum resistance to corrosion. These alloys have lower specific gravity and excellent mechanical properties. Their machinability is good, and they take and maintain a white polish. Alloys containing magnesium in suitable proportions as the hardener are even more resistant to corrosion than those containing silicon, especially against high octane aviation spirit.

Magnesium-Copper-Aluminium Alloys

These alloys are excellent heat-treatable alloys; magnesium added to the binary copper aluminium alloys increases the response of these alloys to heat-treatment, especially the full solution plus ageing treatment, with resulting increase in hardness and strength with sacrifice of ductility.

Nickel-Magnesium-Aluminium Alloys

Nickel with magnesium in aluminium alloys is very effective in maintaining the high properties at elevated temperatures and in providing an alloy not subject to permanent growth on heating. These alloys retain strength up to 315 deg. C. They respond well to heat-treatment and become very hard after complete ageing following the solution treatment.

TABLE III.—*Comparative Properties of a Heat-Treated Aluminium Alloy vs. Other Metals—Equal Weight Ratios.*

	Relative weight.	Tensile strength. Tons per sq. in.
Mild steel	4.4	26.8
Alloy steel	4.4	44.7
Aluminium alloy, cast, heat treated (Alcoa 220-T4)	4.4	55.0
Aluminium alloy, wrought, heat treated (Alcoa 24 ST)	4.4	83.9
Magnesium alloy, cast, heat treated (Dowmetal-H)	4.4	64.8
Magnesium alloy, wrought, heat treated (Dowmetal-E)	4.4	82.6

Sand Castings

Sand casting of aluminium alloys is the method most frequently resorted to in obtaining castings for aircraft construction. Wood patterns are frequently used, but metal patterns are desired where there is quantity production. There is practically no limit to the size or core complexity of castings made by this method. Such foundry considerations as section thickness, gating, risering, chilling, pouring temperature, permeability and moisture content of the sand, and any other factors which influence the rate of metal solidification, have a material effect on the mechanical properties of the castings.

Cast aluminium alloys have now strength at temperatures just after solidifying and, if free contraction of the metal is not permitted, cracks may be produced in the castings. Therefore, the sand moulds must be relatively soft, and cores must soften at low temperatures in order to obtain sound castings. The low specific gravity of the aluminium alloys makes extra

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* Extracted from "The Iron Age." The author is Chief Metallurgical Engineer, Eclipse Aviation Division of Bendix Aviation Corporation, Bendix, N.J.

venting necessary so that all gases can be moved rapidly from the moulds. Either dry or green sand cores are used.

Sand casting alloys may be cast in the smaller castings with ¼-in. minimum wall thickness. The usual allowance for machining is ⅛ in. The shrinkage allowance for patterns is ⅜ in. per ft.

The normal aircraft sand casting alloys are known in the trade as Alcoa 43, Alcoa 47, Alcoa 142, Alcoa 195, Alcoa 214, Alcoa 220, Alcoa 355, Alcoa 356 and their A.S.T.M. or S.A.E. equivalents. Other manufacturers use their own trade names for these alloys.

A listing of typical sand casting alloys is shown in Table IV, and the same table shows the physical properties of these alloys.

The uses and characteristics of these sand casting aluminium alloys are shown below:—

Alcoa 43 (*Al* 93; *Si* 5).

Alloy of low tensile and low yield strength. Due to its high fluidity it is used for complicated and thin walled castings. It is dense, leak-proof, and has good corrosion resistance.

TABLE IV.—*Composition and Physical Properties of Aluminium Sand Casting Alloys*

Composition (typical):

	Cu.	Si.	Fe.	Mg.	Ni.	Al.
2Alcoa 43 ..	—	5	—	—	—	Balance
2Alcoa 47 ..	—	12.5	—	—	—	Balance
2Alcoa 122 ..	10	—	1.2	0.2	—	Balance
2Alcoa 142 ..	4	—	—	1.5	2	Balance
2Alcoa 195 ..	4	—	—	—	—	Balance
2Alcoa 214 ..	—	—	—	3.8	—	Balance
2Alcoa 220 ..	—	—	—	10	—	Balance
2Alcoa 355 ..	1.3	5	—	0.5	—	Balance
2Alcoa 356 ..	—	7	—	0.3	—	Balance

Properties (typical):

	M.S. Tons per sq. in.	P. Tons per sq. in.	E. per cent.	Compressor Tons per sq. in.	Brinell hardness.
Alcoa 43 ..	8.5	4.0	6.0	4.5	40
Alcoa 47 ..	11.6	5.0	8.0	5.0	50
Alcoa 122-T2 ..	11.2	9.0	1.0	8.9	75
Alcoa 122-T61 ..	16.1	13.4	1.0	19.2	100
Alcoa 142-T2 ..	12.1	8.0	1.0	8.0	75
Alcoa 142-T61 ..	16.5	14.3	0.5	21.0	100
Alcoa 195-T4 ..	13.8	7.1	8.5	7.1	65
Alcoa 195-T6 ..	16.1	10.0	5.0	11.2	80
Alcoa 214 ..	11.2	5.4	9.0	5.4	50
Alcoa 220-T4 ..	20.1	11.2	14.0	11.6	75
Alcoa 355-T4 ..	13.4	8.9	4.0	11.2	60
Alcoa 355-T6 ..	15.6	11.2	3.5	12.9	80
Alcoa 356-T4 ..	12.5	7.1	6.0	8.0	55
Alcoa 356-T6 ..	14.3	10.0	4.0	10.0	70

NOTE.—Data taken from the Aluminium Co. of America records. Heat treatment designations: T-2 = annealing treatment; T-4 = solution treatment; T-6 = solution treatment plus ageing; and T-61 = solution treatment plus ageing.

It is used for carburetters, hot-air scoops, fuel-line fittings, fuel and oil-tank flanges, oil pans, gear-case covers and accessory housings.

Alcoa 47 (*Al* 87.5; *Si* 12.5).

An alloy of higher silicon content than Alcoa 43, with subsequent higher strength when modified. It is the lightest and most fluid of all the aluminium alloys, but is more difficult to machine and tap. Its uses are the same as for Alcoa 43, but for thinner walled and more complicated castings, and also for castings requiring higher mechanical properties.

Alcoa 122 (*Al* 88.6; *Cu* 10; *Fe* 1.2; *Mg* 0.2).

This is a heat-treatable alloy used for parts subject to high temperature and requiring high hardness and strength. It is used for pistons, carburetters, intake manifolds, bearing surfaces and air-cooled cylinder heads.

Alcoa 142 (*Al* 92.5; *Ni* 2.0; *Cu* 4; *Mg* 1.5).

This is a heat-treatable alloy, known also as "Y" alloy. It maintains its strength well at elevated temperatures up to 315 deg. C. It is used for cylinders, air-cooled cylinder heads, pistons and bearing surfaces.

Alcoa 195 (*Al* 96; *Cu* 4).

This is one of the most commonly used heat-treatable alloys, having good strength and high shock resistance. It is not as corrosion resistant as the silicon-aluminium alloys, but machines better and has greater strength. It is used for most structural castings, gear cases, crankcases, gear housing, oil pans, controls, rudder pedals, sockets, horns, some cylinder heads, propeller gear boxes, superchargers, transmission gear cases and covers for dirigibles, and also starter and generator housings.

Alcoa 214 (*Al* 96.2; *Mg* 3.8).

This alloy does not respond to heat-treatment. It is more difficult to cast than the Cu-Al and Si-Al alloys, and is not recommended for intricate or leak-proof castings. It has excellent corrosion resistance, high ductility, and strength intermediate between Alcoa 43 alloy and the heat-treated alloys. It is used for housings and parts of simple design requiring high corrosion resistance.

Alcoa 220 (*Al* 90; *Mg* 10).

This is a heat-treatable alloy of excellent resistance to corrosion, especially to high octane aviation spirit. It is not recommended for leak-proof castings, castings of thin-walled sections, or for castings for use at elevated temperatures. The alloy is more difficult to cast than the other aluminium base alloys, requiring special sand and handling practice.

Alcoa 355 (*Al* 93.2; *Si* 5; *Mg* 0.5; *Cu* 1.3).

This is one of the best alloys, as it has excellent casting qualities and retains its strength well at elevated temperatures up to 200 deg. C. It is leak-proof and pressure-tight. It also responds well to heat-treatment. It is used for liquid-cooled cylinder heads, cylinder blocks in liquid-cooled engines, propeller gear-boxes, gear housings, superchargers, crankcases, accessory housings, etc. It is also used for cylinder heads in air-cooled engines of intermediate h.p.

Alcoa 356 (*Al* 92.7; *Si* 7; *Mg* 0.3).

This alloy is used as a substitute for Alcoa 195 when the casting is very complicated. Ageing alone will improve the properties, but quenching and ageing will produce the maximum properties. It is used for cylinder heads and cylinder block in liquid-cooled engines. It is also used for many of the applications referred to under the Alcoa 195 alloy.

(*To be continued.*)

Manganese Bronze Test-Bars

Like "Foundry Practice"—the house organ of Foundry Services, Limited, of Long Acre, Nechells, Birmingham, 7—we, too, have received inquiries as to the best method of making manganese bronze test-bars, and an article appearing in one of their recent issues is reprinted by permission.

If such test-bars are improperly cast, an alloy with a calculated tensile strength of 30 to 40 tons per sq. in. may give under test only 10 to 20 tons per sq. in., and good castings may be scrapped on these figures. The importance of correct casting can easily be appreciated, and although, on account of its peculiarities, the casting of a test-bar in manganese bronze requires a fair amount of metal, nevertheless this is both necessary and economical to obtain consistently the required figures.

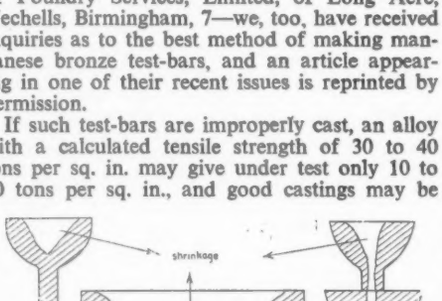

FIG. 1.—METHOD OF CASTING A MANGANESE BRONZE TEST-PIECE, SHOWN AS DOTTED LINE.

The success of casting manganese bronze test-bars may be said to depend on three factors:—(1) melting practice; (2) pouring temperature; and (3) moulding to overcome the shrinkage of the alloy and the oxide film.

Melting Practice

It is essential that an efficient oxide removing flux should be used, as the presence of aluminium oxide and manganese oxides is very detrimental. The melting should be conducted as quickly as possible and the metal should be vigorously fluxed just prior to withdrawal of the metal from the furnace.

Pouring Temperature.—The pouring temperature for manganese bronze test-bars should lie in the range of 960 to 1,000 deg. C.

Moulding.—The excessive shrinkage of this alloy and its tendency to oxidise during pouring with the result that a heavy oxide skin is trapped on the top side of the bar, necessitate special precautions in moulding to overcome this trouble. The procedure is to take a down-gate and feed into the bar in the usual manner. To eliminate oxide and shrinkage, a riser 4 in. high is taken along the whole length of the test-bar. Shrinkage is then confined to the riser in which the dross, dirt and oxide also collects, leaving the bar sound.

Fig. 1 shows the method of moulding and also gives some idea of the shrinkage experienced, the position of the bar which is cut off from the riser and machined to size being indicated by dotted lines.

Effect of Composition on Tensile Strength.—The tensile strength of this group of alloys can be varied by slight alterations in the proportions of manganese, aluminium and iron present, and Table I furnishes a guide.

TABLE I.—*Influence of Composition on the Tensile Properties of Manganese Bronze.*"

Alloy no.	Sn	Cu.	Fe.	Al.	Mn.	Zn.	Tensile strength. Tons per sq. in.	Yield point. Tons per sq. in.	Elongation on 2 in.
1	—	54	1.0	0.25	1.75	43	32.10	14.1	30
2	1.0	55	1.9	0.50	0.10	42	37.19	19.1	21.3
3	—	52.4	—	2.00	3.6	42	41.10	20.0	21.5

Electric Furnaces in the Steel Industry

A review of electric furnace practice in the steel industry was made by H. E. Phelps, of the Rotary Electric Steel Company, Detroit, at a recent meeting of the Association of Iron and Steel Engineers, in a Paper entitled "The Economics of Electric Furnaces for Steelmaking." He dealt with operating costs, production techniques and control of quality, and discussed the challenge of the electric furnace to the open-hearth furnace.

Sand Testing with Special Reference to Flowability and Deformation*

By Wm. Y. BUCHANAN

At the presentation of the author's last Paper[1] on Sand Testing, there was very little discussion, the subject matter being rather difficult to contradict successfully on a first hearing. One or two members, however, appeared to be not quite in agreement with all the ideas for modifying or improving the existing generally-used A.F.A. methods. Others do not appear to grasp quite why these modifications as suggested by the Author are required at all.

During the past few years various lines of argument have been put forward, mainly with the object of eliciting a clear explanation. In this the author appears for the most part to have failed.

However, one very good contribution to the discussion, written privately, is worth quoting extensively as it probably furnishes about the best case for the opposition and may represent the views of others who have perhaps not taken as much trouble to express themselves so clearly.

The author has always held that, whether or not the A.F.A. test procedure is maintained exactly as at present, though of considerable importance, is nevertheless not so important as the fact that if used in its present form, the interpretation of the test figures and their application to foundry practice should be carried out having due regard to the inherent defects in the design of the test-piece and other influences to which the method of ramming is subject at all times. These defects in design and influences affecting the formation of the A.F.A. test-piece, which tend to perform the function of the red herring in the well-known adage, have been clearly demonstrated with extensive experimental evidence in the author's previous Papers on the subject.

A Written Criticism

The extracts from the written discussion already referred to are given below in paragraph form for convenience of reference in the reply.

Paragraph 1.—" . . . . In the first place I would like to underline several sentences in the Paper, such as 'Sand testing is among the most difficult forms of mechanical testing to perform with the degree of precision one associates with the mechanical testing of metals.'

'The subject is not one to be tackled by mere deduction and argument.'

'Sand testing is by no means above ambiguity.'

'The rate of loading does not seem to have any effect on the compression strength.'

'Since the A.F.A. test piece is most commonly used by those in the committees dealing with the matter, it must be accepted as the standard for general use.'

'The A.F.A. procedure may be referred to as a test-piece made by a standard ramming machine, where the machine only is standard, the degree of ramming varying with all conditions.'"

Paragraph 2.—" It is very difficult to give a close definition to such terms as '*Standard Ramming*' and '*Degree of Ramming*,' and this accounts for much of the ambiguity and misunderstanding. To my mind, it is sufficient to regard the A.F.A. ramming procedure as a 'standard method,' and to assess the results accordingly. Provided this attitude is adopted I think the A.F.A. procedure is satisfactory, and there is no need for the complications of the '*Index of Ramming*' with its need for the determination of the true density of every sand mixture tested."

Paragraph 3.—" I understand that the index of ramming is used to calculate the green apparent density to which a sand should be rammed so that each test-piece contains the same volume of dry solid matter regardless of moisture content, grain size, distribution bond, and specific gravity. Thus, with a sand of uniform grain-size, each test piece would always contain the same number of sand grains no matter what the moisture content."

Paragraph 4.—" I agree that a good moulder will tend to control the energy of his ramming so as to produce the required *results* (*e.g.*, high permeability here, high strength there, and so on throughout the mould), but when you associate your index of ramming method with this idea, I think you reveal one of its shortcomings. For, by trying to simulate good moulding in the ramming of test pieces, you are virtually 'trying to control the *results* by varying the ramming energy,' thus in Fig. 1 both methods give test-pieces of equal permeability at 10 per cent. moisture, but as the moisture is decreased the index of ramming method requires an increase in ramming energy to raise the green apparent density so as to maintain the dry apparent density constant in accordance with the chosen index of 13. This increase in ramming energy neutralises the effect of reduced moisture, and it is not surprising that the permeability remains constant in spite of decreased moisture content when the ramming is controlled in this way. In your own words you are 'trying to control the results by varying the ramming energy,' and consequently your results are biased because they are based on biased ramming."

Paragraph 5.—" I am afraid I am not very wise on flowability and deformation, but have always understood that flowability increased with moisture content, yet in Fig. 9 you show the reverse of this. Perhaps it all depends on what you mean by flowability, and is this term suited to the testing method adopted? Does not the bottom hardness depend on the compressive strength of the sand more than anything else, as on this property depends the transmission of ramming force from one end of the test-piece to the other."

Author's Reply

With reference to *Paragraph 2*, it might be said that, merely calling the A.F.A. system of making the test-piece a standard method does not remove its defects. It is better considered as a standard ramming machine which produces test-pieces subject to variations due to changes in flowability, uneven ramming, wrong proportions for compression testing purposes, etc. The flowability of the sand greatly influences the results by the A.F.A. method in a number of ways, as has been shown in a Paper given by the Author to the Birmingham Branch of the Institute. This work should stand at least until refuted by equally conclusive work on the subject. "The subject is not one to be tackled by mere deduction and argument."

With reference to *Paragraph 3*, the statement here is quite correct. The same Index of Ramming may be called the same degree of ramming.

The line of argument at the beginning of *Paragraph 4* is not correct. The errors which occur in the A.F.A. test-piece due to changes in flowability in the sand are not always reflected in moulding practice as is always assumed by advocates of the method, and in fact the Index of Ramming system of control produces test-pieces more representative than the A.F.A. because the Index of Ramming chosen for routine testing is determined by making hardness or ramming measurements on moulds. Thus the Index of Ramming may represent a single specific mould or part thereof or by taking an average figure to represent a group of moulds. It is true that in the Index of Ramming method all variable factors set forth here are under control, whereas in the A.F.A. method none of them is under control, and they all affect the A.F.A. test-piece, even to the degree of uniformity of ramming or lack of it, in the test-piece. The argument in *Paragraph 4* seems to be put the wrong way round when one is supposed to be examining the effect of moisture and not the secondary effect it produces in the ramming of the test-piece. By using a combination of the two methods, after some of the more serious defects in the A.F.A. test-piece, such as the lack of uniformity, have been removed, the primary effect of the variable can be assessed separately from the combination of the primary effect and the secondary or flowability effect as given by the A.F.A. test.

In *Paragraph 6* one is reminded again of the second sentence quoted in *Paragraph 1* from the author's previous Paper.

If flowability be not understood then it is not surprising that the Index of Ramming appears an unnecessary refinement. The I. of R. method alone or in combination with the A.F.A. improved as suggested, is, in the present Author's opinion ideal, being comprehensive, highly informative, and adaptable to any form of routine test or investigation.

The compression strength in the green state is the opposing property to flowability, but it cannot be assumed that flowability is governed entirely by compression strength because plasticity is also an important factor, and although these properties are closely connected they must be assessed separately and problems connected with them investigated experimentally. Fig. 9 of the last Paper shows the relation between flowability, compression strength, and deformation.

The Effect of Moisture on Irvine or Similar Clay-free Sand

Dearden[2] examined the effect of moisture on this class of sand as a foundation for his study of the general effect of moisture on moulding sand. It was stated that while the moisture percentages used included those too low and others too high to have any relation to useful moulding sands, the trend of the tests in these extreme ranges would help to clarify conclusions in more normal ranges of moisture.

The present Author doubts whether there is any practical significance in this line of research, since in no case is a moulding sand composed of clay-free material and clean water. Even the case of loam, which has been brought in, with its excessive moisture content consists of grains of sand and a thin slurry of clay wash. Conclusions and research on moulding sand testing should, however, not be based on work done on loam, as the conditions in loam are unusual and not in the least representative.

However, it has been suggested that this line of work, *i.e.*, the effect of water additions to clay-free sands, would provide some proof of the intrinsic value of the A.F.A. method of making the test-piece, and some very definite conclusions were arrived at. For example, *that silica and other clay-free sands would not ram any harder with increased moisture.*

* A paper prepared for presentation to the Lancashire Branch of the Institute of British Foundrymen.

This, of course, is in direct contradiction to the underlying idea of the present author's statement that the A.F.A. test-piece is at all times subject to the effect of flowability in the sand being tested, since here is an example of a sand which, though not a legitimate example of a moulding sand, yet is good enough for the sake of the argument. In Dearden's example he found that, though the A.F.A. test-piece made in the standard way increased rapidly in weight over 2 per cent. moisture, the dry weight of the test-piece remained constant; that this increase was due only to the additional weight of the water. This, in effect, means that he concluded that the sand had a constant flowability.

The present Author checked this, using Irvine sand for comparison, when it was found that a distinct flowability was present even in this type of sand. With three blows of the A.F.A. rammer, this sand is inclined to be over-rammed, and it would not be surprising to find the flowability of the sand masked in these tests.

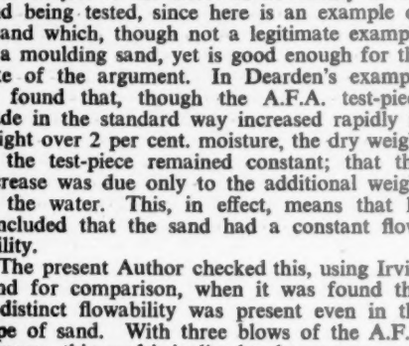

Fig. 1.—Effect of Moisture on Irvine Sea Sand rammed by the A.F.A. Rammer, showing Considerable Change of Flowability.

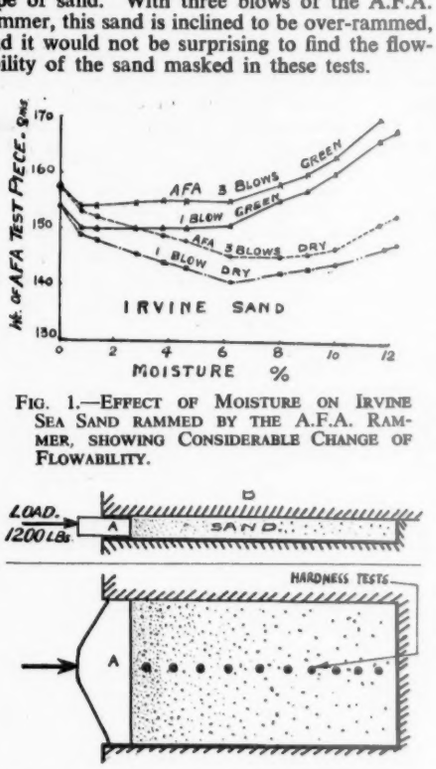

Fig. 2.—Diagram of Kyle's First Method of Measuring Flowability of Sand.

Fig. 1 shows a series of test-pieces made by the A.F.A. standard rammer, using three blows, and repeatedly using one blow to give lighter ramming. Since the same sand is used throughout the series, the true density is the same throughout, and so the Index of Ramming can be retained constant by keeping the dry apparent-density or dry weight of the test-piece constant with increase in moisture. The green-strength and permeability number will, of course, follow the trend of the change in weight of the dry test-piece, so the graphs of the dry weight of the test-piece against moisture are sufficient for the present purpose.

It will be seen from the dry weight that the degree of packing is greatest at 0 per cent. moisture, and that from 0 to 6 per cent. the moisture progressively reduces flowability, when it begins to rise again up to 12 per cent. Here, then, is distinct evidence of a flowability change, and where the effect of moisture alone was to be studied there is a combination of the flowability effect and the true moisture effect in the A.F.A. test results and conclusions drawn therefrom. The effect of moisture on the other types of sand given in Dearden's Paper have been covered in a previous Paper by the present Author, in which the need for separating the true effect of moisture from the flowability effect is shown, and there seems little need to repeat it here.

Flowability

Flowability is the property which enables sand to flow throughout the mass when ramming energy is applied to the outside of that mass. This property is possessed in a varying degree by all moulding sands, and must be considered in relation to mould finish and freedom from voids or loosely packed areas, which in turn cause roughness or even ragged projections on the casting due to metal penetration. Very high flowability is found in oil sand, bonded with, say, pure linseed oil and very low flowability in certain types of heavily-bonded "steel" sands.

For machine moulding, using well-finished pattern plates, a sand having good flowability is essential, otherwise much additional hand-moulding will be required on what should otherwise be a finished mould. In addition, low flowability will greatly increase the effort required in ramming the mould, whether by hand, jolting machine, or jolt-squeeze machine.

The only Papers dealing with the subject of flowability, apart from the Author's work is that of Kyle which appeared recently in the A.F.A. publications, and that of Dietert and F. Valtier, also in the A.F.A. publications in 1934. This Paper by Kyle is well worth studying because he has not merely quoted available data but has set about the study of the subject independently, and the value of the Paper to the foundry industry is enhanced by the scarcity of similar independent research from other sources. While the present Author would not care to recommend the methods put forward by Kyle for measuring flowability in foundry practice, the value of the work in the Paper is not detracted from on that account.

In this Paper, the suggestion is made, or inferred, that flowability has two distinct phases, first, the flow of the sand as force is applied during a moulding operation; and second, the flow of sand due to the weight of molten metal in the mould during casting. This point of view is rather interesting but its development into any real practical application may be quite a different matter because the principle underlying this idea would make it possible to have a set of conditions where a sand would flow readily under pressure of the metal at a later stage. These preparations are contradictory, because a good flowability during moulding would hardly disappear later unless ramming was reasonably near the limit and at best the second stage of flowability is merely the completion of a moulding operation. On that account the method proposed by Dietert has some theoretical interest because the hardness can be recorded after each successive blow of the rammer and the degree of ramming carried to any extreme. While this method may give data of theoretical interest primarily, as concerning the behaviour of sand under a particular set of conditions, the present Author has always contended that the Dietert and Valtier method was not representative of foundry practice so far as moulding is concerned. It would, no doubt, furnish some information if a particular mould were rammed to a hardness equivalent to the A.F.A. test-piece made by four blows of the rammer, in which case the probable tendency to swelling under metal pressure would be indicated by the reading of flowability obtained.

Kyle describes three methods for measuring flowability: (1) A hardness gradient method of his own design; (2) a hardness differential method somewhat similar to the present Author's method; and (3) sand movement method as used by Dietert and Valtier. The third method was used by Kyle to get comparison with the other two methods on which he was working.

It should be noted here that the present Author's method was put before the Institute's Sub-Committee on Sands at least two years before Dietert's sand movement method was published and it might usefully have been considered then. The method of measuring the hardness was by the Author's own penetration hardness tester at first, and later, more conveniently by Dietert's small hardness gauge. The present Author's method of measuring flowability consists of a 2¼ in. by 1¼ in. diameter test-piece of the same equivalent weight as the standard A.F.A. test-piece, and rammed by squeezing in one direction only, then tested for hardness top and bottom by Dietert's hardness gauge. For routine tests a weight of sand equivalent to that found in the A.F.A. test-piece is used and when studying the effect of specific variables like moisture, the test-pieces can be made to the same Index of Ramming. The exact degree of ramming of any mould or part thereof can thus be reproduced for the determination of flowability if required.

Fig. 3.—Compression Testing Machine specially made for Deformation Tests.

$$\frac{\text{Hardness Top}}{\text{Hardness Bottom}} \times 100 = \text{Flowability per cent.}$$

It is true that a difference exists between a test-piece made by a steady squeeze and one formed by any kind of blow; but it is not thought that two types of flowability test are necessary for sands intended for squeezing machines on the one hand and jolting machines on the other. The test-piece made by compression as described should cover both.

Kyle does not consider that it is likely that the ratio of top hardness to bottom hardness in a test-piece can be used for deep moulds because of the difficulty of eliminating errors due to the "non-uniform placement of sand during ramming."

Whilst agreeing with the underlying idea of this statement, namely that the best type of test would really be on a full practical scale, *i.e.*,

that all moulds should be tested in some direct way, but this of course is impossible in practice, and it is for this very reason that small tests have been developed in sands and in other lines as well, as for example in metal testing.

Then again the "non-uniform placement of sand" in a mould is not a function of flowability proper, but is dependent on the condition of the sand, such as the relative degree of aeration in preparation and the method and degree of care in filling the box before ramming.

First Method of Measuring Flowability as Used by Kyle

With reference to Kyle's first method for measuring flowability (see Fig. 2), the metal mould has a sand capacity of 1 in. by 12 in. wide and a maximum length of about 12¼ in., with one end of the mould fixed and the other end movable. For filling, the movable end A is placed at a definite position, and sand sieved into the mould as carefully as possible so as to give good distribution, and struck off level with a straight edge. The top of the mould B is then put in position and secured. A load of about 1,200 lbs. can then be applied, and this constitutes a squeeze test, or the mould may be set up vertically on a special jolter in order to produce a jolt-test, or similarly a jolt-squeeze test may be made. The top B is then removed and the hardness measured by Dietert's hardness tester down the centre of the exposed sand surface. On consideration of this method it will be observed that there are several distinct objections to it. First, the apparatus required is both large and heavy. Secondly, a special machine may not be available for the application of a load of the order of 1,200 lbs. Thirdly, the quantity of sand used for each test is controlled by volume.

It is well known that where, say, a bucket is filled with sand by sieving from a fixed height and striking off level, the weight of sand filling the bucket varies with the moisture content, and that the weight decreases rapidly as the moisture increases to the best temper figure and then above that figure the weight again increases.

The present Author carried out a good deal of work in an attempt to apply the measurement of sand by volume instead of by weight in the making of the small 1½ in. by 2½ in. test-piece. This was recorded in a Paper given to the Edinburgh Section of the Institute. On encountering the above-mentioned phenomenon the method was shelved. Kyle's test is evidently subject to this effect, and in order to check this, a mould was made in wood to the required dimensions and filled, as directed, by sieving and striking off level. At about 8 per cent. moisture the successive weights in three consecutive tests were:—2,315 gms.; 2,223 gms., and 2,200 gms., showing a decrease probably with drying of the sand.

Then the sand was dried to 6 per cent. moisture and the tests were:—2,390 gms.; 2,452 gms., and 2,515 gms., showing a decided increase in weight as the moisture further decreases. The size of the sample makes it difficult to keep the moisture constant during testing. The figures clearly show that the method of filling introduces a very important variable, *before* the ramming force is applied for the flowability test proper, and this point should be kept in mind. The error is likely to be accumulative at times, and when it is so, it will give an apparent sensitivity to the test-piece which may prove misleading. The only way to eliminate this factor, is to use the Index of Ramming method of determining the weight of sand to be used for each test.

Another point in connection with Kyle's test, is the necessity for drawing a graph which might be eliminated by merely using the hardness measurements at the top and bottom, which give the same information as the graph. In this case, the test would become much the same as that of the present Author, except for the variation of weight with moisture as referred to above. The same might apply to any variable affecting flowability such as clay and the like, the flowability of the sand would be seriously affected by the weight of sand for the test, and this would be distinct from the flowability of the sand under pressure during test, although the test-graph obtained would be the result of their combination. The application of so heavy a load to the movable part of the test would require a large machine and probably a somewhat critical rate of loading.

TABLE II.—*Author's Sand Tests showing Agreement, in Duplicate Tests. Dry Sand Sampled on December 26, 1940.*

Mixture	2½ barrows black sand (95 per cent.,; 1 shovel rock sand (3 per cent.); and 10 lbs. Bentonite (1.4 per cent.)													
Moisture	8.2 per cent.; 8.0 per cent...													Averages. 8.1 per cent.
Permeability ..	9.8 cms. 31 secs. .. .. } 99.6..													99.6
	9.8 cms. 31 secs.													
Green strength (compression)	21½ lbs. 20½ lbs. 20½ lbs.													6.68 lbs. per sq. in.
Dry strength (compression)	440 lbs. 460 lbs.													143.3 lbs. per sq. in.
Deformation (W.Y.B. method)	50 51 52 51 50													25.4 thous. or 0.0254 in. per in.
Flowability (W.Y.B. method)	Bottom 42 46 48 46													65.9 per cent.
	Top 74 75 73 75 = 61.3 per cent.													
	Bottom 51 52 51 54													
	Top 71 73 75 74 = 70.8 „													
	Bottom 47 46 52 52													
	Top 76 76 77 78 = 64.2 „													
	Bottom 52 52 53 54													
	Top 74 76 73 74 = 71.0 „													
	Bottom 52 52 52 51													
	Top 75 77 77 78 = 67.3 „													
	Bottom 48 48 50 51													
	Top 80 79 82 82 = 60.9 „													
Flowability. Kyles method. A.F.A. test piece, 1 blow ¼ in. ..	Bottom 18 18 19 18													43.2 per cent.
	Top 34 39 37 35 = 50.3 per cent.													
	Bottom 18 18 17 22													
	Top 37 39 40 41 = 47.8 „													
	Bottom 19 21 20 19													
	Top 37 36 34 39 = 54.1 „													
	Bottom 9 12 10 14													
	Top 25 35 34 33 = 35.9 „													
	Bottom 9 8 16 12													
	Top 26 34 31 29 = 36.7 „													
	Bottom 9 11 13 20													
	Top 42 38 41 38 = 34.4 „													

Second Method for Measuring Flowability used by Kyle

The second method of measuring flowability used by Kyle consisted of an A.F.A. test made by one blow of the rammer falling ¼ in. and testing for hardness on the top and bottom. The test-piece was made two inches long as usual but the manner in which the rod and weight of the rammer was lowered on the sand appears to affect the result by its effect on the preliminary condition of the ramming.

Consecutive tests from the same batch of sand taken from a mixing drum in order to prevent variations of moisture during testing, gave the figures shown in Table I.

TABLE I.—*Flowability Results using Dee Fert's Hardness Gauge.*

Readings.							Flowability. Per cent.
Top	42	45	39	40..	..	..	55.0
Bottom	22	23	27	18..	..	..	
Top	35	36	32	28..	..	..	48.5
Bottom	18	16	14	17..	..	..	
Top	30	32	34	30..	..	..	68.0
Bottom	20	18	20	25..	..	..	
Top	28	30	31	36	..	..	48.5
Bottom	12	17	15	16..	..	..	
Top	28	31	28	35..	..	..	65.5
Bottom	16	17	23	25..	..	..	
Top	29	30	34	35..	..	..	55.0
Bottom	20	13	18	19..	..	..	

The figures of Table I were obtained whilst taking care to lower the rammer and weight on to the sand as gently and as near as possible with the same amount of care. These figures indicate that to get a 2 in. test-piece, a weight of sand as low as 142 gms. was required instead of the usual 170 gms. and the test-piece produced has a hardness much below that of normal practice, even on the top, while the bottom hardness has no relation to moulding practice. The figures also show that duplicate measurements on the ends of each test-piece are not in good agreement, and also that the percentage flowability expressed by these consecutive tests is variable—the range being from 48 to 68 per cent.

The effect of the degree of care with which the rammer is lowered was found to have a considerable influence on the figures, thus:—

Top 39 43 42 42 / Bottom 19 30 22 26 } yielding 58.4 per cent. flowability, when the rammer was lowered with moderate care.

Top 42 36 34 35 / Bottom 10 16 18 24 } yielding 46.3 per cent. flowability, when the rammer was lowered with special care.

Thus the personal element appears to have too much influence on the results of this test. The A.F.A. test-piece is too short or squat for a test of this kind, having been designed to eliminate the degree of hardness difference, which Kyle now seeks to magnify sufficiently to serve as a flowability measurement.

Third Method of Measuring Flowability used by Kyle

The third method used by Kyle for measurement of flowability was that developed by Dietert and Valtier. The amount of contraction in the length of the A.F.A. test-piece during ramming, between the fourth and fifth blow of the rammer, is measured in thousandths of an inch and taken as a measure of flowability.

With regard to this method Kyle found that "the property being measured seems to be something akin to flowability but the method of expressing the results gives the reverse indication." The present Author has always held the opinion that tests of this kind should not be carried out at a degree of ramming which is so much above that required for normal moulding practice and would be inclined to seek another method on that account alone.

Deformation Test

The green-strength alone is unsatisfactory, and may indeed be definitely misleading, because a high green-strength can be associated with a dry brittle sand, which is unfit for moulding. The term moulding signifies the need for plasticity, and it is this plasticity which is measured by the deformation test. The lack of "deformation" will result in a bad draw associated with additional patching, which itself will be difficult to accomplish for the same reason.

Author's Method for Deformation Determination

The wooden block used in the test hitherto was replaced by a specially made gauge, constructed of light steel tube and disc ends. This turned out test-pieces weighing 135 grms., *i.e.*, not heavier than the A.F.A. test-piece, which is usually about 170 grms. It was carefully ground to 2.000 in. and kept in a small felt-lined box when not in use. This gauge is used to calibrate the machine, and is found to be much better than the wood block. Good apparatus is essential in sand testing, and the failure of most attempts to use the deformation test in one form or other is doubtlessly due to lack of accuracy in the machines.

The procedure is as follows:—

(1) The test-piece is placed in the machine and the length measured with a light load of 1 lb. to ensure that all the backlash in the system is taken up.

From this reading any variation from "true" (2.000 in.) is noted, and this reading, say 12 thousandths, may be positive or negative.

(2) The load is then applied steadily until the point of commencement of fracture, taking care not to over-shoot the mark, and the reading in pounds and fractions taken as well as the micrometer reading. The maximum compression strength reading is best obtained using a loose pointer, and this applies more particularly to the deformation test.

(3) Without moving the load screw, the compression plate of the machine is then depressed in order to allow the introduction of the 2.000 in. gauge. This operation brings the pointer of the spring balance to a much higher reading, and, by rotating the load-screw carrying the micrometer, the pointer of the spring balance is returned to the exact reading of the maximum strength already noted. The difference in these micrometer readings between the maximum-compression reading on the deformed test-piece and the spring-balance reading when the 2.000 in. gauge is substituted is the deformation, except for the necessary length correction, as the A.F.A. test-piece is, of course, never exactly 2.000 in. The preliminary length measurement furnishes by comparison with the 2.000 in. gauge the correction to add or subtract.

The plates of the machine must at all times be quite free from grains of sand, as these introduce errors in measurement. The slides of the compression motion must be quite free, as even a slight friction will readily introduce errors in the micrometer readings. The test-piece should be well formed, with the faces parallel, and have no ragged edges likely to crumble in handling and so introduce grains of sand between the test-piece and the compression plates. However, with these precautions, which, after all, are an every-day necessity in all cases of measurements of these dimensions, duplicate tests give very close results.

The A.F.A. test-piece, if made by the standard drop-weight, should be made as already indicated, with the tube floating on the third blow, and if the tube has a slight clearance on the rammer head, a horseshoe-shaped distance-piece, such as described in previous Papers, should be used in order to hold the tube quite vertical during the first and second blows, and thereby ensure that the test-piece faces are quite parallel. A distance-piece of about $\frac{1}{4}$ in. thickness seems quite sufficient for the purpose.

Examples of duplicate tests on the same sample of sand gave the following deformation on 2 in.—55, 54, 56, 54, 53 thousandths when carried out after one day's practice with the apparatus.

Table II gives a series of tests as used by the present Author carried out on one sample of sand which was kept in a mixing drum throughout the testing in order to eliminate drying, and this procedure is strongly recommended.

Preparation of the Sample

The sand was mixed in a No. 2 Simpson mixer, aerated, put through a $\frac{1}{4}$ in. mesh riddle, and transferred to the mixing drum for testing.

Moisture

The moisture percentage was obtained by direct weighing after drying.

Making the Test-piece

The test-piece is rammed by the method suggested in previous Papers, two blows with a distance piece under the tube or mould and the third blow with the tube free to move. This procedure makes a test-piece which, although not perfect is at least much freer from uneven ramming across both the horizontal and vertical sections. The Author strongly recommends this practice both to the individual foundryman and also to the American Foundrymen's Association Sub-Committee on Testing.

Permeability

The permeability numbers are calculated from readings of time and pressure during test, using the standard formula.

Green Compression Strength

This test is carried out on the spring balance type of machine incorporating the improved B.C.I.R.A. arrangement to eliminate side movement in the piece as illustrated in Fig. 3.

Deformation

This test is incorporated in the green-strength test, and presents no difficulty as a routine test, provided it is not attempted on the actual foundry floor. The duplicates are very good indeed and require no further elaboration.

Dry Strength

This test is carried out in the Author's hydraulic machine such as was put before the Sands and Refractories Sub-Committee, and has been used in one or two forms elsewhere with varying degrees of success.

Flowability

This test has been carried out on both the present Author's method and that of Kyle nearest to it. Both of these methods are fully described elsewhere in the Paper.

REFERENCES

[1] FOUNDRY TRADE JOURNAL, March 14, 1940.
[2] FOUNDRY TRADE JOURNAL, February 9, 1939.

Some Jobbing Foundry Experiences—XXI

By "TRAMP"

Although the majority of loam moulds are swept around a vertical spindle, occasionally jobs lend themselves to horizontal sweeping. Jobbing shops handling a variety of large cylindrical castings are usually equipped with a box such as is shown in Fig. 1. This consists of a special end A in which a square bar as Fig. 2 suits. The ends A and B being bored and the spindle turned at C and D, accuracy is assured. Fig. 3 illustrates a typical casting made by this method; it is essentially a body with two flanges and an enlarged portion in the centre to act as a belt pulley for driving. As this casting is used in operations subjected to abrasion, it is cast of a hard iron mixture; consequently the flange and belt portion cannot be machined, and absolute accuracy is required in registering the

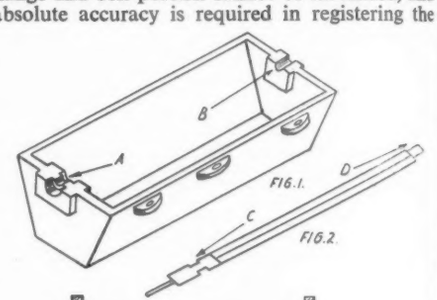

FIG. 1.

FIG. 2.

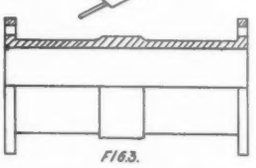
FIG. 3.

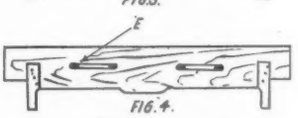

FIG. 4.

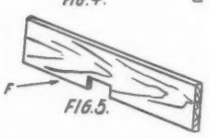

FIG. 5.

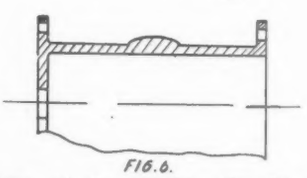
FIG. 6.

two halves of the mould. By the method adopted this is easier of attainment than by moulding in sand and guiding by box pins. The sweeping board required is shown in Fig. 4. This is secured to a spindle as Fig. 2 and placed in the box. Bricks are then built in the box corresponding to the outside of the mould and a layer of loam swept on, the board being pulled around by two wrought iron handles, E, Fig. 4. Having completed one half, the sweep is transferred to the other, and a similar operation performed. The joint of each box being trued by the use of a staff (Fig. 5), with a metal protected edge F, before the sweep is removed. The centre core is struck up on a core barrel with ends turned to suit A and B, Fig. 1. This ensures centrality of core and correct setting lengthways. This latter point is of very great importance in jobs in which a metal thickness is defined by the end setting of the main core (Fig. 6). On closing, location is effected by the end A and the top-half secured by suitable clamps.

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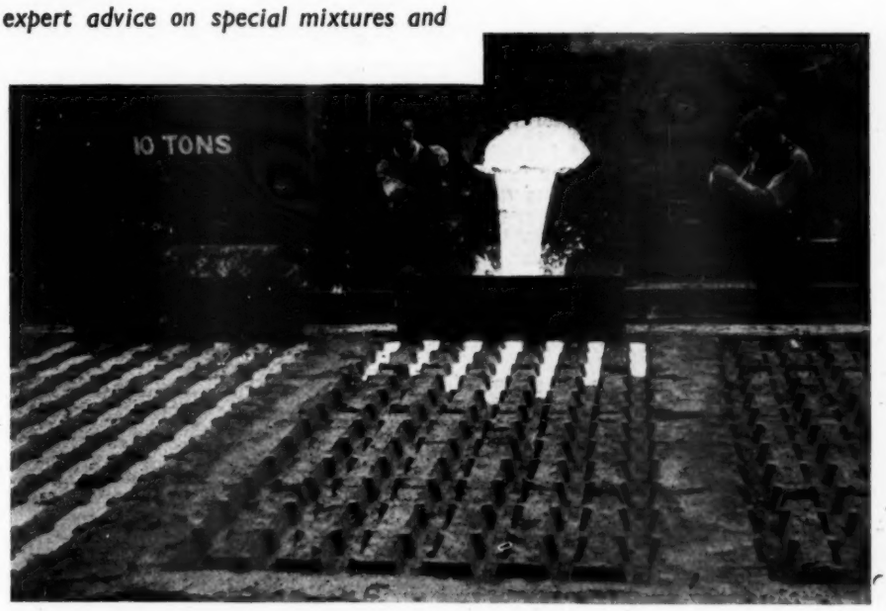

THE STANTON IRONWORKS COMPANY LIMITED, NEAR NOTTINGHAM

Some Notes on Bell Founding*

FUNDAMENTALS IN DESIGN

By J. M. STONES

In the construction of large bells, it is of great importance to know the proportions between the dimensions which are most advantageous for the production of sound. The principal conditions for a good bell are:—

(1) The greatest diameter of the bell must be at the mouth, and the greatest thickness of metal must be at the sound-bow.

(2) A bell should at the utmost measure in width fifteen times, and in height (measured obliquely on the outside) twelve times the thickness of the sound-bow.

(3) The thickness of the bell decreases from the sound-bow up to half its height, and from there on should amount only to one-third of the thickness of the sound-bow. From the sound-bow to the circumference of the mouth, the thickness also decreases.

(4) The diameter of the mouth of the bell should be twice as large as that of the uppermost part of the crown.

(5) The weight of the clapper should be about 1-40th that of the bell. For very large bells a weight of 5 to 10 lbs. may be added to the clapper.

(6) The ball of the clapper, *i.e.*, its round or pear-shaped end, should be thicker in the proportion of 5:3 than the thickness of the metal on the sound-bow. However, this applies chiefly to bells weighing over 120 lbs.

Tracing the Profile

The correct profile of a bell of given diameter is traced in the following manner; small variations being, however, customary in many foundries. Suppose the horizontal line *a b* in Fig. 1 is the prescribed width of the bell at its mouth—divide this line into 15 equal parts, which are called "Prims," because one such part represents the thickness of the bell on the prim or sound-bow. The diameter of the bell thus divided serves as a measuring scale in the following operations:

First divide *a b* by the lines *c f*, *d g*, and *e h* into equal parts; *f h* now gives the diameter of the cap, which is one-half the diameter of the mouth. Now measure off, with the compasses, twelve prims, and with the distance thus obtained intersect from the point *e* the line *e h* in *i*, then draw the line *b i* and divide it into twelve equal parts; with the radius *b k* which is equal to 1½ prims, describe an arc from *b*.

By now cutting off a prim from *k* to *l*, the thickness of the bell on the sound-bow is obtained. After drawing the line *l b* erect upon *m*, as the centre of *b i*, a perpendicular, and set off upon it a piece, *m n* = 1½ prims. The point *n* determinates how far the curve of the bell recedes in the centre of the height.

The curve itself consists of two parts, *n k* and *n i*, of different curvatures. To trace it, find with a distance of 30 prims from *n i* an intersecting point *o*, and from there describe with the radius *o n*, the arc *i n*. Further, set off upon the line *m n* from *n* to *p* 1-3rd prim, and describe from *o* with the radius *o p* the arc *p q* for the interior curve of the upper half of the bell.

The interior curve of the lower half has to be drawn from another centre. For this purpose we find with a distance of 12 prims from the point *p* and *l* a centre *r*, and describe from it the arc *p l*; then from the points *n* and *k* find, with a distance of 8 prims, a point *e* which gives the centre for describing the arc *n k*.

Finally, with a distance of 8 prims intersect from the terminal points *a* and *b* of the line *a b*, the axis *d g* of the bell in *t*, and from the latter point, describe with the radius *t i* the arc *i n* for the curvature of the cap. The cap receives a thickness of 1-3rd prim, and hence its internal curvature is described from the centre *t* with a radius which is 1-3rd prim smaller than *t i*. For the better securing of the crown upon the bell, the thickness of the centre cap is increased by 1-3rd prim, which is designated *w x*.

Exterior Tracing

The exterior shape of the bell traced according to the rules given is frequently subject to small variations—for instance, by rounding off *i* and *u* on the edge of the cap, as well as *k*, and by hoops and rods arranged in different parts on the surface, partly for the sake of increasing the strength, and partly for ornamentation.

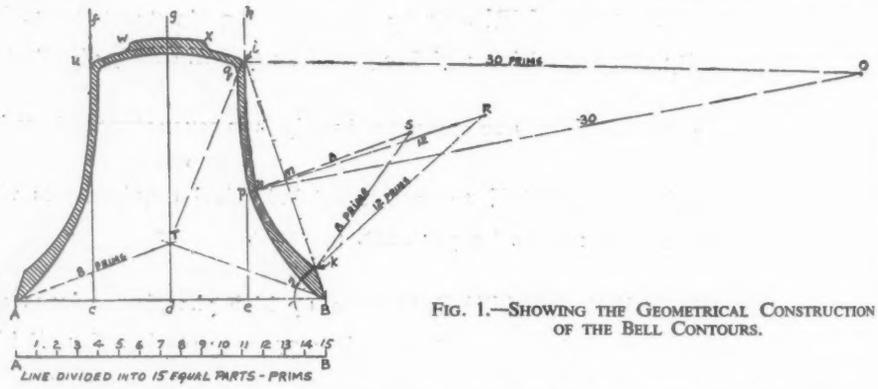

FIG. 1.—SHOWING THE GEOMETRICAL CONSTRUCTION OF THE BELL CONTOURS.

Thus it is seen how difficult the construction of bells is, and that every part must be strictly cast in accordance with its proportions. If bells of a fixed weight are to be cast, a normal bell of known tone, dimensions and weight is used for calculation. However, such calculation is not applicable to very large bells, and, hence, must be constructed to a given formula.

Though the moulding of large bells may be considered a good job of work, the casting requires the same attention and equal skill, in order to obtain a pure, harmonious tone; the slightest inaccuracy or defect in casting destroys the harmony, and spoils the bell.

The exact tune of a set of bells, as they come out of the moulds, is a secondary consideration, because the notes can be altered a little either way by cutting, but the quality of the tone will remain the same for ever, except that it gets louder for the first two or three years that the bell is used, probably from the particles arranging themselves more completely in a crystalline order under the hammering.

Hanging of Bells

The usual method of hanging bells is to cast six ears or loops on the top of the crown of the bell; these are called canons, through which iron hooks and straps are put in, to fasten the bell to the stock. This method of hanging by canons is, no doubt, objectionable, as they must always be the weakest part of the casting, from being nearest the top, and in practice it is found that they frequently break off, and have to be replaced by iron bolts put through holes drilled in the crown. It is also difficult to turn the bell, in the stock, to present a new surface to the clapper, when it is worn thin in one place.

In some bells these disadvantages are avoided by casting a very short, thick, hollow neck with a strong flange round the top, which can be fastened to the stock by hooked bolts. By this arrangement the bell is held by a large section of its own metal, and can at any time be shifted round by slackening the bolts. If a clapper is to be used, it can be hung upon a separate bolt, passing through the hole in the neck, and through the stock, and secured above.

When only clock hammers are employed to strike on bells, the wear is so small that the facility of turning the bells is of secondary importance. This plan has the recommendation of great strength, and would probably have been used to a larger extent but for the loss of the canons, which are regarded by the founders as an ornamental finish to bells, upon which they rather pride themselves.

In calculating the sizes of bells to produce particular notes, and assuming eight bells are made of similar material and their sections are exactly similar figures in the mathematical sense, they will sound the eight notes of the diatonic scale, if all their dimensions are in the proportions, 60, 53½, 48, 45, 40, 36, 32, 30, which are merely convenient figures for representing the inverse proportions of the times of vibration belonging to the eight notes of the scale, so that if it is required to make a bell a fifth above a given one, it must be two-thirds of the size in every dimension, unless it is intended to vary the proportion of thickness to diameter, for the same rule then no longer holds good, as a thinner bell will give the same note with a less diameter.

Moulding Large Bells

These are moulded in loam, which should be sifted very finely. In the centre of the pit a post is driven into the ground—around this a wide platform of bricks is built upon which the core is erected in brick. This core is hollow, and, to enable the moulder to make a fire in it, is provided with flues for the necessary draft. About half the height of the core a spindle base is laid upon the post, and bricked in the wall of the core; the spindle is then set up, and moulding continues in the ordinary way. The core is first built up, and then the thickness put on, and the outside built up.

In casting bells, it is a rule to melt the metal as rapidly as possible, keeping the surface covered with charcoal; when the metal is melted, a sample is taken out with a ladle, cast in sand, and examined as to grain and fracture, before casting.

Bell metal is best composed of 80 parts copper and 20 parts tin, or 78 parts copper and 22 tin. There are, however, variations from these proportions, and small accidental or intentional admixtures of zinc and lead, for instance, 71 parts copper, 26 tin, 1.8 zinc and 1.2 iron—or 80 parts copper, 10.1 tin, 5.6 zinc and 4.3 lead.

For house bells the following proportions may be recommended:—Copper, 4 parts; tin, 1 part. For tower bells, copper 32 parts, tin 9; and for very large tower bells, copper 16 and tin 5.

* A paper presented at the January, 1941, meeting of the South African Branch of the Institute of British Foundrymen, Dr. Van Eck presiding.

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The Week's News in Brief

Trade Talk

THE GOVERNMENT OF INDIA has assumed control of the sale and use in manufacture of existing stocks of unmanufactured and semi-manufactured aluminium in order to ensure they will be utilised to the best advantage.

THE STANDARD BRASS, IRON & STEEL FOUNDRIES, LIMITED, of Benoni, have recently completed the manufacture of an acid resistant Sulzer pump casing weighing as cast 5½ tons. It is one of the largest castings to be made in the Dominions.

THE UNITED STATES is showing more interest in the South American wolfram ore market. Japan is still the largest buyer of wolfram from this source, and is reported to have paid up to 100s. per unit for shipment some time ago in order to secure supplies.

OWING TO the heavy volume of orders requiring to be financed in wartime, the directors of Ransomes & Rapier, Limited, have decided to amend the Articles of Association so as to remove the borrowing limit they impose. An extraordinary general meeting is to be held on April 25 at which the necessary resolution will be submitted.

TO ENABLE the company to achieve a larger production, the directors of Smethwick Drop Forgings, Limited, recommend an increase of the capital to £325,000 by the creation of 150,000 5½ per cent. cumulative redeemable preference shares of £1. An extraordinary meeting has been convened for April 26, at which the necessary resolution will be proposed.

THE MEMBERSHIP of the Ironfounding Workers' Association shows a decrease of 1,793 during the last year. This is due, according to the secretary, Mr. Hugh Murdoch, Falkirk, to the fact of many of the men having, during the slack period, gone into other factories and later others taking up munitions work. While at the end of the previous year there was an unemployed list of 1,000, the total at the end of 1940 was 200.

THE MALLEABLE IRON DIVISION of the General Motors Corporation of Saginaw has announced the modernisation of its foundry. Two cupolas and an electric furnace are to be added to the melting equipment. The daily melt will be increased from 1,000 to 1,400 tons, and 200 more men employed. The conveyor system is to be revamped so as to give straight line production, which is thought to make for safer working conditions.

ACCORDING TO Mr. S. D. Scully, steel controller for Canada, the Canadian Government is prohibiting the use of steel except for war purposes. In order to conserve steel supplies for ships and other war industries, no permits are to be granted except in emergency for the use of steel in the Dominion for the construction of schools, industrial or commercial buildings, bridges, churches, or other structures of the kind.

THE CANADIAN iron and steel industry is operating at the highest rate in its history with a backlog of orders sufficient to assure the maintenance of capacity operations for many months to come, reports the Royal Bank of Canada. Facilities are being extended to meet the enlarged demand. Production of pig-iron in Canada in 1940 was 61 per cent. greater than in 1939, and the output of steel ingots increased 48 per cent. Automobile plants have been active with over 75 per cent. of their output comprising military vehicles. Shipbuilding is more active than in many years. Activity has been general in the mining industry, preliminary estimates placing the value of the 1940 output at an all-time record, probably as much as $550,000,000, as compared with $475,000,000 in 1939. The nickel and copper industries reported the most active year in their history, more nickel was sold than in any previous year, and all copper available is finding ready markets, 80 per cent. being taken by Great Britain and the remainder in Canada. Iron ore was produced at the New Helen mine in the Michipicoten area in Ontario, the extraction of this ore having been recommenced in 1939 after a lapse of sixteen years. Coal operations were generally at a high level with output up to the end of November at 15,800,000 tons, against 14,200,000 tons at the same date in the previous year. Nova Scotia mines expanded production to meet the augmented requirements of the steel industry in that province. Western Canada also reported increased output.

Personal

MR. ARTHUR H. GIBBARD has retired from the general secretaryship of the National Brass and Metal Mechanics' Association. He is succeeded by Mr. A. R. Penny.

MR. E. S. WHALLEY, managing director of the Vulcan Foundry, Limited, and Major E. C. Straker, chairman of Robt. Stephenson & Hawthorns, Limited, have joined the board of the North British Locomotive Company, Limited.

MR. AND MRS. THOMAS ROSS, who are well known in the trade in the West of Scotland, have celebrated their golden wedding. Mr. Ross is head of the firm of William Ross & Sons, brassfounders and engineers, of Thistle Street, Glasgow.

LORD DUDLEY GORDON was elected president for the second year in succession at the annual meeting of the Federation of British Industries, held in London on Wednesday. Lord Dudley Gordon is chairman of J. & E. Hall, Limited. He began his working life as an apprentice in an Aberdeen shipbuilding yard and continued his training with a firm of engineers in the Midlands. He joined the firm of which he is now head in 1907. He is an ex-president of the British Engineers' Association.

LT.-COL. W. A. VIGNOLES, D.S.O., owing to a long and severe illness, has been obliged to relinquish his appointment as senior managing director of Evershed & Vignoles, Limited, electrical instrument makers, of Chiswick, London. Mr. J. C. Needham succeeds him in that capacity, and Mr. M. Vines and Mr. D. D. Walker have been appointed additional managing directors. Col. Vignoles, who is rapidly regaining strength, remains a member of the board of the company. He worked as an apprentice with the predecessors of the company, W. T. Goolden & Company, joining that firm nearly fifty years ago.

Wills

JARVIE, W., a director of Bairds & Scottish Steel, Limited, and William Baird & Company, Limited ... £37,523

LANG, CHARLES RUSSELL, senior director of G. & J. Weir, Limited, Holm Foundry, Cathcart, Glasgow ... £77,886

Company Meeting

Vickers, Limited

At the annual meeting of Vickers, Limited, MR. A. A. JAMIESON (chairman) said that the whole strength and energy of their group of companies were directed to ensure that punctual deliveries of their products were made to the Service departments. He acknowledged the co-operation of the departments in their efforts to carry on production. During the past year there had been many difficulties to overcome, but the staff and workpeople had proved that they were competent to foresee and to overcome difficulties which appeared to be truly formidable.

Reports and Dividends

Murex, Limited—Interim dividend of 7½ per cent. on the ordinary shares (same).

Blythe Colour Works, Limited—Net profit for 1940, £18,679 (against £38,831 in 1939); ordinary dividend of 5 per cent. (20 per cent.); taxes, £9,691; to general reserve, £5,000; carried forward, £6,021 (against £11,783).

A. Reyrolle & Company, Limited—Profit for 1940, after providing for depreciation and taxation, £169,471 (against £162,213 in 1939); brought in, £146,638; dividend of 7 per cent. on the preference stock, £7,175; final dividend of 7½ per cent. on the ordinary stock, making 12½ per cent. for the year (same); to general reserve, £60,000 (£40,000); carried forward, £146,845.

British Oxygen Company, Limited—Profit for 1940, £1,897,508 (against £1,387,995); depreciation, £451,108; income-tax, £404,228; retained by subsidiaries, £86,703; reserved for E.P.T., income-tax and war contingencies, £600,000; ordinary final dividend of 8 per cent. (10 per cent.), making 15 per cent. (17 per cent., plus 20 per cent. share bonus, for 1939); carried forward, £34,207 (£40,258).

Obituary

MR. WILLIAM GORDON LIVINGSTONE, late assistant secretary of the Iron Trades Employers' Insurance Association, Limited, Glasgow, died last week.

IT IS with sincere regret that we announce the death of Mr. W. W. Scales, who was, until ill health compelled his resignation, editor of the [South African] "Engineer and Foundryman."

MR. JAMES ANDERSON, Glasgow district manager of the Skefko Ball Bearing Company, Limited, died in Glasgow last week at the age of 65. He was well known in machinery and engineering circles. In the Great War he was at Zeebrugge and was mentioned in dispatches.

MR. WILLIAM GORDON LIVINGSTONE, who was well known to the trade in Scotland as assistant secretary to the Iron Trades Employers' Insurance Association, Limited, of Glasgow, died at Helensburgh on April 9. He had had a long association with this trade group and was known to most of the firms in the West of Scotland.

BY THE DEATH of Mr. William Thornton, of Bradford, at the age of 80, Yorkshire has lost one of its most prominent foundrymen. He joined his father's firm, Thornton & Crebbin, Limited, and later was a director of Cole, Marchant & Morley, Limited. In 1926 he joined the directorate of Yorkshire Repetition Castings Company, Limited, of which concern, his son, Mr. W. G. Thornton, is managing director. To Mr. W. G. Thornton, who is widely known in connection with his activities in connection with the West Riding Branch of the Institute of British Foundrymen, we extend our sincere sympathy.

WE REGRET to record the death of Mr. C. R. Messinger, a past-president of the American Foundrymen's Association. It was in 1923 that he assumed office, and behind the scenes he did much, together with the late Mr. Oliver Stubbs and the late Mr. Tom Firth, to establish co-operation between the A.F.A. and the Institute of British Foundrymen. After graduating at Yale, he was successively connected with the Harbison Walker Refractories Company; Sivyer Steel Castings Company; Nugent Steel Castings Company; Chain Belt Company; Federal Malleable Company; Oliver Farm Equipment. At the time of his death he was on the directorate of a number of Milwaukee concerns, both banking and industrial.

SIR NIGEL GRESLEY, chief mechanical engineer of the London & North Eastern Railway Company, died at Hertford on April 5. Born in 1876, he was educated at Marlborough, and after serving his apprenticeship with Mr. F. W. Webb at the Crewe works became a pupil of Sir John Aspinall at the Horwich works of the Lancashire & Yorkshire Railway. In 1905 he entered the service of the Great Northern Railway as carriage and wagon superintendent at Doncaster. In 1911 he was appointed locomotive engineer of the same railway, and when it was merged in the London & North Eastern Railway he remained as chief mechanical engineer of the amalgamated company. For the Great Northern he produced his first Pacific engine in 1922, and when the 100th Pacific was completed in 1937 and named after its designer, it was stated that he had been responsible for the design and construction of between 1,400 and 1,500 locomotives, at a cost exceeding £7,000,000. He was knighted in 1936.

New Companies

(From the Register compiled by Jordan & Sons, Limited, Company Registration Agents, 116 to 118, Chancery Lane, London, W.C.2.)

Emerson (Metals), Limited—Capital, £3,000. Subscriber: F. W. Smithson, "East Bend," Oval Waye, Ferring-by-Sea, Sussex.

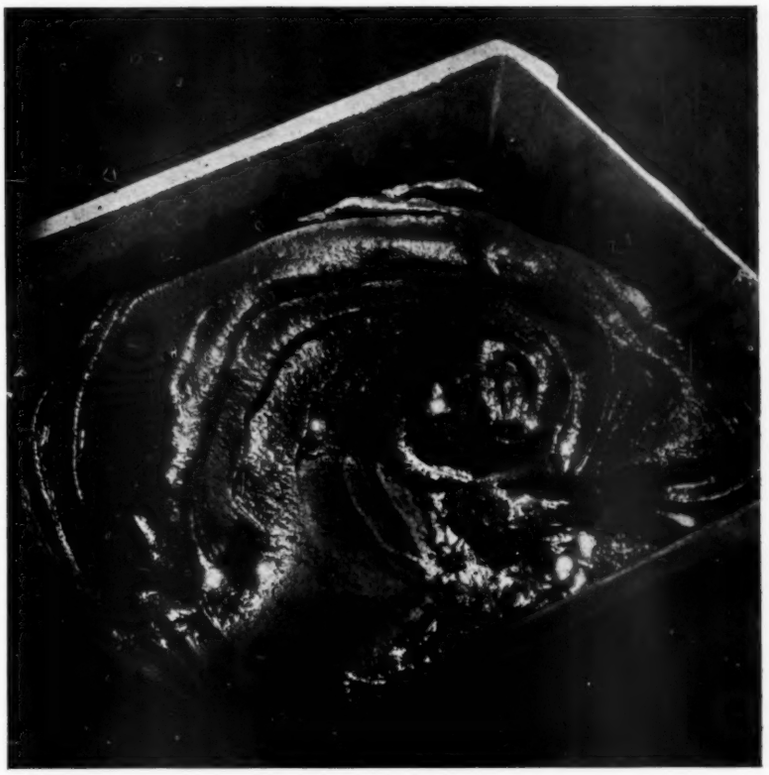
Holehouse Furnace Company, Limited—Capital, £6,000. Manufacturers of mechanical stokers, etc. Subscriber: C. Ferdinand, 136, High Street, Wibsey, Bradford.

Frost (Rochdale), Limited, Eagle Ironworks, Crawford Street, Rochdale—Capital, £10,000. Mechanical engineers and machinists. Director: W. Frost.

General Salvage, Limited—Capital, £10,000. Buyers and sellers of metals, tools, waste goods, etc. Subscriber: L. M. Mott, 5, Fordwych Road, London, N.W.2.

Andrew Fraser & Company, Limited, Astor House, Aldwych, London, W.C.2—Capital, £25,000. Engineers. Directors: A. Fraser, A. J. Russell, and C. G. Gosden.

Watch this Dictator of Firebrick Life



THERE are some users of refractory bricks who are curiously careless as to the cement they employ. Whilst insisting upon sound and suitable bricks they build them with an inferior cement. They let cement dictate the life and durability of refractory bricks. The shrewd refractory user knows that a dependable cement is worth its cost many times over. Experience shows that in structures jointed with ordinary fireclay, extensive erosion originates in the joints. Joints made with any of the following cements are as hard and mechanically strong as the firebricks.

DURAX No. 3 is a 42/44% alumina, air-setting, high temperature jointing cement suitable for bonding firebrick linings working under high duty conditions. A special feature of Durax No. 3 is its fine grading, which not only gives the cement good "workability" and makes it easy for the mason to use, but also permits a brick-to-brick joint which is so desirable in furnace construction. To obtain the maximum length of service from your firebrick linings, specify Durax No. 3 Refractory Cement for jointing.

PYROLYTE H.T. CEMENT (air setting) for jointing basic bricks in re-heating furnaces, and also for jointing and wash-coating firebricks where furnace conditions produce erosive slag.

DURAX No. 3 REFRACTORY CEMENT (air setting) for jointing and wash-coating all types of firebricks, working under normal and high duty conditions.

SINTEX "D" AND "W" (air setting) for jointing siliceous and semi-siliceous bricks, and also for patching gas retorts and coke oven linings.

GENERAL REFRACTORIES LTD.

HEAD OFFICE: GENEFAX HOUSE, SHEFFIELD, 10. TELEPHONE 31113 (6 LINES)

G.P.19

FIREBRICKS: *Glenboig Special, Glenboig Special Crown, Glenboig, Glenboig Crown, Castlecary, Dykehead, Gem, White Carr, Stour, Hycone, Alumantine, Hysilyn, Adamantine, Llangennech.*
BASIC BRICKS: *Spinella, Saxpyre, Supermag, Diazite, Dolomax.*
ACID-PROOF REFRACTORIES: *Obsidianite, Losol.*

INSULATION: *Amberlite* Bricks, Cement and Concrete.
SILICA BRICKS: *Lowood, Meltham, Allen, Quartex.*
CEMENTS: *Sintex, Durax, Pyrolyte.* PLASTICS: *Durax, Rotaline, Plastic K-N., Glendoline, Ground Ganister, Steel Moulders' Compositions.* SILLIMANITE: Tank Blocks, Bricks and Cements. SANDS: Moulding, Brick Facing, Silica, Glass.

Raw Material Markets

Only a short break was allowed in any section of the iron and steel industries at Easter, and the works are again in full production. Similar conditions were observed among consumers, many of whom, being employed on work of the utmost urgency for various Government departments, could not afford the lengthy holiday usually associated with Eastertide. Speciality engineers' order-books are almost completely in the hands of Government departments, and no relaxation can be expected in conditions among these establishments over a long period ahead; in fact, full-scale operations are assured during the continuance of hostilities. Some light-castings makers are receiving more work of an official nature, although the trade generally is disappointed at the slow influx of Government specifications, more especially so as their normal peacetime outlets have been greatly restricted. A feature of the steel industry is the ever-increasing pressure for deliveries of special qualities for the production of munitions. The revised provisions for the taxation of excess profits announced in the new budget have been welcomed as a step in the right direction by the heavy industries generally, although many of the earlier criticisms of the Chancellor's methods of taxing commercial concerns still remain.

Pig-Iron

MIDDLESBROUGH—Output of Cleveland foundry iron is but a mere trickle of the quantity required to meet the needs of consumers in this district, the bulk of whose requirements are now being satisfactorily met by ironmakers in the Midlands. Basic iron is the chief product of the Cleveland furnaces, and is in great demand by the steelworks. Additional tonnages of ordinary foundry iron are being taken up by heavy engineers, thus reducing the pressure on special qualities of iron, but the demand by light-castings makers is comparatively small, as many works are by no means fully employed. There is a slightly better tone in the industry now that Government work is being shared among makers a little more freely, but if contracts of an official character are to compensate makers in full for the loss of peacetime business much more work will have to be handed out.

Every encouragement is given to hematite users to make use of refined and ordinary common foundry irons where practicable in order to relieve the heavy demand for hematite, home production of which is insufficient to satisfy the full needs of buyers. The task of discriminating between the various applications for licences belongs to the Control authorities. Iron is distributed only to priority consumers, but users in this category are being compelled to utilise other grades of iron if satisfaction can be obtained in this way. The Control is able to supply imported iron to make up any deficiency in local outputs, although foreign material is being conserved as far as possible.

LANCASHIRE—Pig-iron from Derbyshire and Staffordshire makers is reaching consumers in this area satisfactorily in most instances, although increased allocations for stocking purposes would be welcomed. Heavy electrical engineers, machine-tool makers and other speciality establishments continue to absorb the bulk of the iron coming into the district, activity among jobbing and light-castings foundries being only moderate. Most of the latter are able to work good time as yet, but the state of order-books does not indicate very active conditions in the future unless additional work is forthcoming.

MIDLANDS—The position with regard to supplies of high-phosphorus iron is very satisfactory; fairly substantial tonnages are being taken up by heavy engineering works, many of which can use this type of iron together with better qualities, which are more difficult to obtain. Priority contracts occupy practically the full attention of these concerns, and order-books are filled well ahead. Light-castings manufacturers, on the other hand, could readily deal with additional business, and are hoping that Government departments will be able to utilise their resources more freely in the future than has been the case up to the present.

SCOTLAND—There is little change to report in the position of light-castings makers, many of whom are in need of more work in order to maintain continuous operations. Certain works in this branch are more fortunately placed, having received contracts for the requirements of Government departments, but, taking the trade as a whole, the situation is not yet satisfactory. Specialised engineers are very actively engaged, and are experiencing some difficulty in obtaining their full requirements of pig-iron, although no interruption of work has been occasioned on this account.

Coke

Coke ovens are easily able to cope with the current demand for foundry fuel, and are also in a position to deliver substantial tonnages for stocking purposes. For delivery to Birmingham and Black Country stations, the quotation for Durham best foundry coke is 61s. 6d. per ton.

Steel

The plate mills are exceptionally busy, priority orders for their product being on a heavy scale. It is necessary, in fact, for the Control to distribute supplies of imported plates, but this is no indication of unsatisfactory outputs by the home works. Structural engineers are calling for slightly increased tonnages of joists and sections, but the reduced activity in building in recent months has been reflected in the demand for these descriptions. There is an ever-increasing demand for special steels wanted for the production of munitions, and it may be expected that pressure on these grades will become even greater.

Scrap

Many consumers of iron and steel scrap are working on very slender margins, stocks having been depleted by recent delays in deliveries. They were keen to lay in additional supplies prior to the Easter recess, but, generally speaking, it was impossible to do this. Steelworks are particularly large users of scrap, and are ready to purchase any material offered. Heavy cast iron for foundrymen is active, and increased tonnages would be welcomed.

Metals

Copper—So long as shipping is not interfered with to any great extent, there is no reason to suppose that the heavy consumption of copper by the war industries will not be met. Empire output is very considerable, while Great Britain is in the fortunate position of being able to procure metal from the Belgian Congo. In addition, substantial tonnages of finished and semi-finished copper products are forthcoming from the United States. More and more of the red metal is being taken up for Government contracts, and it is necessary to restrict distribution among non-essential users to the bare limits as a precautionary measure.

It is understood that the export of raw copper from the United States, in addition to requiring a licence, is now subject to a special clause, which stipulates that, in the event of the metal being wanted for the U.S. defence programme at a later date, the contract will be cancelled. It is believed that the clause has been instrumental in preventing the shipment of 20,000 tons of copper to Japan.

Tin—Several factors have combined to impart an easier tone to the London tin market recently; tin advices from the East have disclosed an easier position, and quietude in the United States and lower Ministry of Supply offers of cash tin have all contributed in part. At times official selling figures in London have been undercut by offers from other sources. It has been suggested that the recent persistent selling by the Ministry of Supply is to influence quotations in a downward direction with a view to affecting the American market similarly. Consumers in America have been paying more than the 50 cents per lb. buying limit of the Metals Reserve Company, and it is thought in some circles that the company has instituted complaints regarding the position, the effect of which is, of course, to delay the steady accumulation of metal under the buying programme for the U.S. Government.

Tin prices on the London Metal Exchange during the past week have been as follow:—

Cash—Wednesday, £270 15s. to £271; Thursday, £268 5s. to £268 10s.; Tuesday, £269 15s. to £270; Wednesday, £270 15s. to £271.

Three Months—Wednesday, £268 to £268 5s.; Thursday, £265 10s. to £265 15s.; Tuesday, £267 10s. to £267 15s.; Wednesday, £268 to £268 5s.

Spelter—While supplies of this metal are ample to meet the heavy demands of the war machine, distribution has to be carefully controlled in order that urgent requirements can be dealt with promptly. In the United States, encouragement is being given to the movement to secure substitutes for zinc. The Administration has decreed that remelted zinc shall not be sold above the price of virgin metal.

Lead—There is no change to report in the satisfactory supply position of lead; while Government orders involve the use of considerable tonnages, there are ample supplies to spare for other inquiries at the present time. It is not expected that there will be any early deterioration in the situation, although the Control authorities are watching conditions carefully, and, if imports become irregular, more rigid conditions will be imposed on allocations.

Distribution of Steel Supplies

The Iron and Steel Control's booklet "Distribution of Steel Supplies, No. 3, Customers," directed that application for steel authorisations should be addressed to the Government Department under whose responsibility the steel was to be used. From now on, applications from certain raw material industries will be dealt with by the appropriate Controller.

In the case of non-ferrous metals, application forms for authorisations of steel for: (1) The manufacture of new plant and machinery; (2) the maintenance and repair of existing plant, and (3) packages and containers, to be used in processes of manufacture of non-ferrous metals, can be obtained from the Non-Ferrous Metals Control, Grand Hotel, 46, Albert Street, Rugby. The processes referred to are:—

(1) The mining, melting and refining of copper, lead, zinc and tin, including the treatment of ores, residues, etc., for the recovery of metal.

(2) The casting, rolling, drawing and extrusion of copper, lead and zinc, brass and other alloys of copper, but not including die castings or the milling of powders from these metals.

(3) The production of nickel, antimony, platinum, and other miscellaneous non-ferrous metals not included under (1) and (2), and their elementary compounds and alloys when produced in the same works, but excluding ferro-alloys, aluminium, magnesium and iridium.

In the case of iron, steel and ferro-alloys, application forms for authorisations of steel to be used in processes of manufacture of iron and steel can be obtained from the Iron and Steel Control, Ashorne Hill, Leamington Spa. The processes referred to are:—

All processes involved in the production of ores, ferro-alloys, cinder and scale, and semi-finished iron and steel as enumerated in the First Schedule of the Control of Iron and Steel (No. 8) Order, 1940; tungsten ore, concentrates, residues tantalum ore; tantalum metal and tantalum compounds; titanium carbide; niobium; chrome ore; wolfram, including wolframite and scheelite; magnesite; and the collection and treatment of iron and steel scrap.

Applications for steel for building should also be referred to the Control in the first instance, although except in cases of new building wholly or partly financed by the Ministry of Supply, authorisations will be issuable by the Ministry of Works and Buildings.